JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE

State of Pennsylvania

AND

AMERICAN REPERTORY.

SEPTEMBER, 1845.

## CIVIL ENGINEERING.

### *On the Expansion of Brickwork, (considered with reference to the Chimney Shaft, at Mr. Cubitt's Works, at Pimlico.)*

Paper read at the Institution of British Architects, April, 1845.

The chimney to which I propose to direct your attention is an object of interest, from the proof it affords of the power of heat, in expanding materials—in which such expansion is generally overlooked. The shaft is encased in a tower, without being any where in contact with it, or any part of the adjoining buildings: great care having been taken while building, to keep the chimney quite free from all the other work. None of the floors or landings of the tower were allowed to touch the shaft; the intention being to permit it to move up and down freely, as the heat acted upon it—thus preventing that displacement of materials in the tower which would otherwise have happened. This shaft is built of brick, which is perhaps of all materials, the least affected by change of temperature, and yet it is found that the shaft differs in height considerably, even with the change arising from the comparatively slight variation in the heat of the smoke and vapors passing through it. This variation is never more than 250 Fahr. and yet the shaft at the height of 90 feet alters, or rises, nearly $\frac{3}{8}$th inch with this change only. This shows that the materials with which an architect, engineer, or builder, has to deal, are always varying in their bulk, and that no two sides of a building are at all times of the same height, except when there is an unusually uniform and still atmosphere; and of course the external walls of the tower which support the floor, from which this variation is measured, are also subject to

constant changes, by alteration in the heat of the atmosphere. Thus it is seen that a variation in size with every change of temperature, must take place in the external parts of all buildings, even a garden wall cannot be of the same height on both sides, when there is more sun, wind, or rain, on the one side than on the other.

The chimney is parallel, and the internal diameter is 5 feet; its neight from the surface is 108 feet. The foundations were laid at a depth suitable to the nature of the soil, being on a layer of gravel 11 feet from the level of the ground; and in order to spread the weight of the building over a large surface, a bed of concrete was formed 23 feet square, and 3 feet in thickness; on this a mass of brickwork 21 feet square, 2 feet thick, was laid in cement, forming a solid block, equal to being in one piece of stone, like a large solid landing, to carry the upper work. In the centre of this foundation, and through the whole of the before-mentioned brickwork, a well 18 inches diameter was left, and taken down below the water line deep enough to insure the lower extremity of a lightning conductor being always under water. The walls of the tower are 14 inches thick from the bottom to the top, and inclose a space of 14 ft. 9 in. square in the clear at base, and 1 foot less at the top: the tower being tapering, stairs are built in the walls for the purpose of communicating with the belfry and clock room, and with a supply cistern for steam boilers; also for easy access to the top of the chimney, to ascertain what is occurring there, with respect to the temperature of the vapors emitted, and that in case too much heat were given out or wasted at the top, where it could no longer be of any service, such waste might not happen without means of ascertaining the fact that it was occurring.

The smoke shaft in the centre is for 24 ft. 3 in. upward, from footings 1½ bricks in thickness; but at the base, where the flues enter, it is strengthened round the openings by an additional brick in thickness. So far the work is done with bricks of the usual form and size; but above this, they are segment-shaped, and were made purposely for the shaft. In the second piece, 11 ft. 3 in. in height, the work is 10 inches thick; in the third piece, 40 ft. 3 in. in height, it is 9 inches in thickness; in the fourth piece, 17 ft. 9 in. in height, it is 8 inches; in the fifth piece, 17 ft. 3 in. in height, it is 7 inches, and in the remaining height the work is 6 inches in thickness.

The first object aimed at in designing the tower, was to conceal the chimney shaft; the appearance of which was thought to be objectionable to the neighborhood. As it was intended that no black smoke should be suffered to escape, it seemed that if the chimney were concealed from view, its existence might remain unknown; but it was also considered that other direct advantages might be gained to justify the erection and compensate for the increased outlay. These expected advantages have been realized.

A considerable saving of fuel has been effected owing to the chimney being protected from a cold atmosphere, from rain or snow beating against it, which would rob it of its heat, in proportion as the evaporation from the outer surface was more or less rapid. There seems, however, as much propriety in protecting a chimney from cool-

ing influences, as there is in clothing any other part of the flue, or steam boiler itself; for in order to insure a sufficient supply of air to support combustion, it is necessary that the ascending smoke and vapors should have been heated, so as to become in the required degree lighter than the external air. In the degree that the strength or force of the draught is required to be increased, so must the air and vapors given off from the furnace be allowed to pass at a higher temperature; consequently the amount of the difference of heat lost from a chimney exposed to the weather, and from one clothed, is by so much a clear gain.

The height of the tower affords sufficient pressure to make available a capacious cistern fixed at its top for supplying the steam boilers with water, thus giving great power to the person who has charge of the engine, should occasion require its being brought into action, either through the failure of the force pump or through evaporation of water from the boilers, or neglect in filling them at the proper time, thereby diminishing to a very great extent the risk of explosion from such causes, or at least rendering the boiler less liable to be deranged.

It will be observed that the shaft is much thinner than it could have been had it been erected without its casing. The quantity of brickwork saved in the shaft, and the economy of fuel, will go very far towards paying the additional cost of the tower, which may therefore be considered as a matter of very little, if any, additional cost, when the advantages are all taken into account. Civ. Eng. and Arc. Jour.

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TO THE COMMITTEE ON PUBLICATIONS OF THE JOURNAL OF THE FRANKLIN INSTITUTE.

GENTLEMEN:

The following article is taken from the Boston Courier, of July 15th. The facts, I believe, are all correctly stated. The tonnage of each year (excepting 1838, of which I have no official report,) corresponds with the amounts contained in authentic documents in my possession.

It is not often that we are able to obtain all the facts appertaining to a case of this sort; and when we do succeed in procuring them, I think they ought to be preserved.

I therefore suggest the propriety of republishing it in the Journal, and am,

Very respectfully, yours,

CHARLES ELLET, JR.

*Boston, July 15th*, 1845.

## *Wear of Railroad Iron.*

There has been a great deal of discussion and speculation during the last two years, as to the probable duration of railroad iron when exposed to a heavy traffic; and there are few subjects on which the opinions of practical men have differed more.

We have, however, at last, the means of forming a very safe estimate of the durability of a 56 pounds to the yard edge rail, when well laid, on an even and well-adjusted track.

The first ten miles of the second track of the Lowell road was first brought into use in 1838, after the "fish-belly rail" had been found inadequate. The new rail was of the H pattern—the form now most generally approved.

The following table shows the number of tons which passed over the road, in each year, from 1838, when this rail was first used, until July, 1845, when the company commenced making extensive repairs:

| | |
|---|---|
| In 1838, about | 60,000 tons. |
| 1839, | 70,000 " |
| 1840, | 73,000 " |
| 1841, | 86,000 " |
| 1842, | 91,000 " |
| 1843, | 115,000 " |
| 1844, | 150,000 " |
| 1845, (to July,) | 75,000 " |
| Total freight, | 720,000 " |
| In addition to this quantity, there has been transported, annually, about 16,000 tons of passengers and baggage, or in seven and a half years, | 120,000 " |
| Which makes the aggregate tonnage about | 840,000 tons. |

One *half* of this quantity only has passed over the second track, which, up to this time, therefore, has sustained 420,000 tons. The question is now, What effect has this tonnage produced? Is the rail visibly injured by it?

The company have relieved us of the necessity of all speculation on this point, by taking up several considerable stretches of this rail in 1844; and they are *now* making still further changes—one about *a mile long*, near the three-mile stone, and the other about *half a mile*, near South-Woburn. They will be compelled to make additional renewals this year, and probably to change the iron on the whole of this ten miles in the next year. The durability of this rail may, therefore, be set down at 500,000 tons. The lowest estimate we have ever seen of the power of a good edge rail, is 1,000,000 tons.

In 1841 and 1842, the Lowell company took up 26 miles of the "fish-belly" rail, and laid down a new iron of about 56 pounds per yard; some portion of it was 60 pounds, and that which they are now using is 63 pounds iron per yard. This change of iron cost $121,559, after deducting the proceeds of the old iron, or about $4700 per mile.

The new iron was heavier than the old, which, of course, increased the cost of making the change; but, on the other hand, the new iron was purchased while railroad iron was admitted free of duty, which *reduced* the cost.

If we make the proper allowance for these two circumstances, we will find that the cost of taking up one track of 56 pounds iron, and

replacing it by a new track of the same weight, is very nearly $5000 per mile.

If we then divide this sum by 500,000 tons, the amount of trade which will have destroyed it, we shall obtain *one cent per ton per mile* for the value of the wear of iron on this road. This is a larger result than we should have looked for; but as the company receive more than *five cents per mile per ton* for all the freight they carry, they can afford to renew their iron and still make reasonable profits.

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*Report of* L. O. Reynolds, *Chief Engineer of the Central Railroad and Banking Company of Georgia, to the Stockholders.*

Engineer's Department, Central Railroad,
Savannah, April 5th, 1845.

*To* R. R. Cuyler, Esq., *President:*

Sir: The period of another annual convention of the Stockholders of this Company being at hand, I submit to you the following Report of the operations of the Road for the last year, and its condition at this time.

The fiscal year of the Company terminates with the month of November, but it was deemed proper to delay the report to the present time, that a supplementary statement may be appended, shewing the operations of the Company as nearly up to the period of the convention of the stockholders as possible.

The following table exhibits the earnings of the Road for the year ending November 30th, 1844:

*Earnings of the Road for the year ending November 30th,* 1844.

| Year | Months. | Num'r of Passen. | Amo nt of Passage Money. | U. S. Mail. | Freight. | Total Receipts. | Total for same period previous year. |
|---|---|---|---|---|---|---|---|
| 1843 | December | 1534 | 3555.19 | $1715 | $25,983.44 | $31,253.63 | $17,453.27 |
| 1844 | January | 1527 | 3956.48 | 1715 | 24,086.99 | 29,758.47 | 19,294.40 |
| " | February | 1574 | 4536.39 | 1715 | 19,453.23 | 25,704.62 | 11,929.95 |
| " | March | 1446 | 4276.75 | 1715 | 19,876.11 | 25,867.86 | 7,944.44 |
| " | April | 1322 | 3237.00 | 1715 | 12,724.87 | 17,676.87 | 7,486.88 |
| " | May | 1669 | 4446.75 | 1715 | 13,930.84 | 20,092.59 | 10,107.07 |
| " | June | 1035 | 2433.18 | 1715 | 6,659.86 | 10,808.04 | 7,707.45 |
| " | July | 1187 | 2267.82 | 1715 | 8,120.82 | 12,103.64 | 8,080.77 |
| " | August | 2632 | 2826.75 | 1715 | 13,639.61 | 18,181.36 | 11,142.77 |
| " | Sept'mb'r | 833 | 1425.88 | 1715 | 32,270.02 | 35,410.90 | 21,447.59 |
| " | October | 1433 | 4340.12 | 1715 | 44,907.60 | 50,962.72 | 35,256.94 |
| " | Novemb'r | 1332 | 3539.00 | 1715 | 45,349.31 | 50,603.31 | 42,612.94 |
| | Total, | 17,524 | 10,841.31 | 20,580 | $ 267,002.70 | $ 328,424.01 | $ 201,464.45 |

Total number of bales Cotton transported during the year, 77,437.

The expenses of working the road for the above period, have been as follows:

*Maintenance of Way*—Including all repairs and materials for repairs of Road, depots, turn-outs, wells, cisterns, bridges, &c., $ 66,273.04

Amount carried forward,

| | |
|---|---|
| Amount brought forward, | $ 66,273.04 |
| *Maintenance of Motive Power and Cars*—Including all materials used in repairs of engines and cars, all labor for the same, wages of engine men, firemen, oil, tallow, fuel, water, &c., | 35,344.43 |
| *Transportation Expenses*—Including depot expenses, wages of conductors and train hands, salaries of agents and clerks, insurance on cotton, damage, &c., | 44,544.44 |
| *Incidental Expenses*—Printing and stationary, | 1,557.61 |
| Total, | 147,719.52 |

RECAPITULATION.

| | |
|---|---|
| Earnings of the Road for the year ending November 30, 1844, | 328,424.01 |
| Expenses for the same period, | 147,719.52 |
| Profits, | $ 180,704.49 |

The earnings for the four months, ending April 1st, 1845, have been as follows:

*Earnings of the Road for the four months ending April 1st, 1845.*

| Year | Month. | No. of Pass. | Passenger and Mail Money. | Bales Cotton. | Total Earning. | Total for same period previous year. |
|---|---|---|---|---|---|---|
| 1844 | December | 1206 | 4,576.88 | 12,517 | 34,886.74 | 31,253.63 |
| 1845 | January | 1345 | 4,755.05 | 14,207 | 31,415.21 | 29,758.47 |
| " | February | 1041 | 4,649.75 | 18,898 | 36,787.40 | 25,704.63 |
| " | March | 1138 | 5,351.13 | 15,260 | 39,248.57 | 25,867.86 |
| | | 4730 | $19.332.21 | 60,882 | $142,337.92 | $112,584.59 |

Increase in these four months over the corresponding period last year, $29,753.33, or 26½ per cent.

The distance run by the trains during the year, is as follows:—

| | |
|---|---|
| Passenger trains, - - - - - - | 119,556 miles. |
| Freight trains, - - - - - - - | 91,298 " |
| Total, - - - - - - | 210,854 " |

In performing this distance, 3605 cords of wood have been consumed, which is one cord for every 59 miles run.

The amount of tonnage transported during the year, is equal to 1,056,128 tons hauled one mile.

It must be borne in mind, that for a considerable part of the year the trains go very light in one direction. In the fall, when the up-freight greatly exceeds the downward, and before the cotton crop begins to come to market, the down trains run nearly empty. The reverse is the case a few months later, when the up freight falls off, and cotton presses forward; and there is a short period in the summer that there is very little freight in either direction. It is presumed

that this irregularity will gradually cease, and that the freighting business will, after a time, be more equally distributed throughout the year. Other articles of transportation, such as lumber, staves, fuel, &c., will seek this channel, and afford freight for the down trains in the summer and fall, when other freight is dull.

The cost of working the Road, and maintaining it during the last year, including all expenses, has been as follows:

| | *Cents.* |
|---|---|
| For maintenance of way per mile run, | 31.4 |
| " maintenance of motive power and cars, | 16.7 |
| " transportation expenses, | 21.1 |
| " contingencies, | 0.8 |
| Total, | 70c. |

The Depot grounds at either end of the Road, were considered amply sufficient for any business that might offer, but the experience of the past year has shown that they must be extended, particularly the cotton yards. It is in contemplation to make additions to them during the present year, and a purchase of ground for this purpose has already been made. The want of a suitable passenger-house at the Savannah Depot has long been felt; a plan has been prepared, and it is proposed to erect the building during the approaching summer.

A small engine house is also required at the centre of the Road, at which a spare passenger and freight engine may be kept to supply the place of any engine that may be disabled on the Road.

Our motive power now consists of sixteen engines, all in working order, except the "Georgia," which we are remodeling. She will be fitted up as a freight engine, with eight wheels.

An order has been given for four more; our number will then be twenty. Eleven for freight, and nine for passengers.

We now have one hundred and fifty eight-wheel freight cars, and intend increasing the number to two hundred for the next season's business.

We have all of our wheels cast at a Foundry in this city, and fit them up in our own shops; by this course we get a more perfect article, and at no greater cost than to order from the North. We have not had an instance of the failure of the wheels and axles fitted up by our own workmen.

The condition of the road is much improved since my last report, and is as good now as at any former period.

The good policy of keeping an efficient force on the repairs is more and more manifest, in the regularity with which the trains perform their trips.

We have now had sufficient experience to enable us to make a fair estimate of the annual cost of keeping up the Road. I find the average duration of pine string pieces is six years; of pine cross-ties, eight years; and of ribbon, four years.

There is in the whole Road about 130,000 cross-ties; 12,300,000

feet (board measure) of string pieces, and 600,000 feet (board measure) of ribbon. We now renew the cross-ties with cypress, which, I think, will last at least ten years.

| | |
|---|---|
| Then $\frac{1}{8}$ or 16,250 cross-ties per annum, at 25 cents, | $ 4,062.50 |
| $\frac{1}{6}$ or 2,050,000 feet (b. m.) string pieces, at $6 per M, | 12,300.00 |
| $\frac{1}{4}$ or 150,000 feet (b. m.) ribbon, at $12 per M, | 1,800.00 |
| Repairs of Trestle-work and Bridges, | 8,000.00 |
| Spikes, | 2,000.00 |
| Deterioration of Iron, | 22,500.00 |
| Repairs of Wells, Pumps, Cisterns, Turn-outs, Depots, Turn-tables, and contingencies, say | 7,987.50 |
| Thirty gangs of Laborers, of six each gang, including Overseers and Supervisors, at $110 per gang per month, | 39,600.00 |
| Salaries of Superintendent and Assistant, | 1,750.00 |
| Total, | $ 100,000.00 |

An average of about $ 526 per mile per annum. The expense during the past year has been $ 348—about two-thirds of the above sum. As the cross-ties and string-pieces of the western part of the Road are as yet not much decayed, and most of the Bridges are sound, it will be some years before the cost of repairs will reach the maximum; but I am confident that with the amount of business that may reasonably be expected, the cost of maintaining the Road will not fall much short of one hundred thousand dollars per annum.

It is not so easy to make an estimate of the other annual expenses attending the operations of the Road, as the maintenance of the machinery and the transportation expenses are governed, in a great degree, by the amount of business done. I am confident, however, that with a business that would yield an income of $ 450,000 per annum, the whole expense of operating the Road would not exceed $ 200,000; and I am equally confident the receipts of the road will, at no distant period, exceed that amount.

The opinions of engineers on the subject of the duration of Railroad Iron, are extremely variant, and the system has not been in operation a sufficient time in this country, to afford data for an exact estimate.

There are about 8000 tons of iron on our Road, which has been laid down an average of five years. On the eastern part of the Road, near this city, several miles have been in use eight years; and during the first year and a half of the time, bore the transit of twelve trains per day in each direction, transporting material for the heavy embankment adjoining the city, and I cannot perceive any difference in the condition of this and other portions of the iron, which have not borne half the amount of tonnage.

I have set down the annual deterioration at five per cent, and I am satisfied that will be found sufficient. The cost, thus far, has not been one-tenth of that sum.

I intimated in my last report the intention of substituting embankments for a considerable portion of the trestle bridging on the line.

We have commenced this operation at the long trestle work near the 100 mile station, and it will be continued on a moderate scale during the year.

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### *Report on the Atmospheric Railway.*

The Select Committee appointed to inquire into the merits of the Atmospheric System of Railway, have examined the matters to them referred, and have agreed to the following report:

Your Committee have given their best attention to this interesting subject. Adverting to the great number of Railway Bills now in progress, they consider that one of the most practical results of this inquiry would be lost if their report were delayed until after these Bills had passed through Committee, and a decision had already been made on their comparative merits.

Your Committee have endeavored therefore to present to the House, with as little delay as is consistent with the due discharge of their duty, the evidence which they have taken, and the opinions to which they have come, and they trust that their labor may not prove altogether useless to the Committees that have to decide on the particular railway schemes now pending.

The House are aware that a railway on the atmospheric principle is already in operation between Kingstown and Dalkey in Ireland.

The first object of your Committee was to make a full inquiry into the result of this experiment. From Mr. Gibbons, Mr. Bergin, and Mr. Vignoles, gentlemen officially connected with the Kingstown and Dublin and Kingstown and Dalkey Railways, they received the fullest and frankest evidence on all the points connected with their management. Your Committee had also the advantage of the opinion of Dr. Robinson, of Armagh, whose scientific knowledge and acquirements render his testimony particularly valuable on the theoretical merits of such an invention.

From this evidence, and from that of Mr. Samuda, it appears that the Dalkey line has been open for nineteen months, that it has worked with regularity and safety throughout all the vicissitudes of temperature, and that the few interruptions which have occurred have arisen rather from the inexperience of the attendants, than from any material defect of the system.

Your Committee find, moreover, that high velocities have been attained with proportional loads on an incline averaging 1 in 115, within a course in which the power is applied only during one mile and an eighth.

These results have been displayed under circumstances which afford no fair criterion of what may be expected elsewhere; for, in addition to the curves on the line, which would have been considered objectionable, if not impracticable, for locomotive engines, there are alleged to exist defects in the machinery and apparatus, occasioned partly by the difficulties of the situation, partly by mistakes inseparable from a first attempt, which very seriously detract from the ef-

ficiency of the power employed, for the remedy of which provision has been made in the experiments now in progress.

These are important facts. They establish the mechanical efficiency of the atmospheric power to convey with regularity, speed, and security, the traffic upon one section of pipe between two termini; and your Committee have since been satisfied, by the evidence of Messrs. Brunel, Cubitt, and Vignoles, that there is no mechanical difficulty which will oppose the working of the same system upon a line of any length. They are further confirmed in this opinion by the conduct of the Dalkey and Kingstown Directors, who have at this moment before Parliament a proposition to extend their atmospheric line to Bray.

In addition to the witnesses already examined, your Committee have had the advantage of hearing the objections urged by Messrs. Nicholson, Stephenson, and Locke, against the adoption of the atmospheric principle, and the grounds of their preference for the locomotive now in use.

Your Committee must refer the House to the valuable evidence given by these gentlemen. It will be seen that great difference of opinion exists between them and the other witnesses to whom your Committee have before referred, both in their estimation of what has already been effected, and in their calculations of future improvement.

But without entering upon all the controverted points, your Committee have no hesitation in stating, that a single atmospheric line is superior to a double locomotive line both in regularity and safety, inasmuch as it makes collisions impossible except at crossing places, and excludes all the danger and irregularity arising from casualties to engines or their tenders. Now the importance of these considerations will be best estimated by a reference to the return of accidents for fifteen months appended to this report. It will there be seen that there have been during that period fourteen collisions upon the road, and thirteen accidents to engines, which would altogether have been avoided on the atmospheric system, and that these casualties entailed the loss of eleven lives, as well as the serious injury of forty-five persons. From the other twenty accidents, common to both systems, resulted only four deaths, and two persons injured. There is certainly one case in which the engine passed uninjured over cattle lying upon the road, together with its entire train; but then against this security derived from the advantage of weight in surmounting obstacles, must be set the great danger to which the engine driver and stoker are exposed, standing as they do upon an open platform.

Your Committee desire also to bring to the attention of the House a peculiarity of the atmospheric system which has been adduced by the objectors to prove how unsuited it must be profitably to carry on a small and irregular traffic; namely, that the greatest proportion of the expenses of haulage on the atmospheric principle are constant, and cannot be materially reduced, however small the amount of the traffic may be. This is, no doubt, a serious objection to the economy of the atmospheric system under the circumstances above alluded to.

But, on the other hand, as the expenses do not increase in proportion to the frequency of the trains, it is to the interest of Companies adopting the atmospheric principle to increase the amount of their traffic by running frequent light trains, at low rates of fare; by which the convenience of the public must be greatly promoted. Upon an Atmospheric Railway the moving power is most economically applied by dividing the weight to be carried into a considerable number of light trains. By locomotive engines, on the contrary, the power is most conveniently applied by concentrating the traffic in a smaller number of heavier trains. The rate of speed at which trains of moderate weight can be conveyed on an atmospheric line, makes comparatively little difference in the cost of conveyance; while the cost of moving trains by locomotive engines increases rapidly with the speed.

Now when it is considered that we surrender to great monopolies the regulation of all the arteries of communication throughout the kingdom, that it depends in a great measure upon their view of their interest when we shall travel, at what speed we shall travel, and what we shall pay, it becomes a material consideration, in balancing the advantages insured to the public by rival systems, to estimate not so much what they respectively can do, but what, in the pursuit of their own emolument, they will do.

The main objections of the opponents of the atmospheric system seem to rest, 1st, on the supposed increased expense of the atmospheric apparatus over and above the saving made in the construction of the road; 2d, on the inconvenience and irregularity attending upon a single line. With reference to the last point, your Committee felt it their duty to direct their first attention to the question of security, and they have already stated that there is more security in a single atmospheric line than in a double locomotive. They may further observe, that they find the majority of the engineers who have been examined are decidedly of opinion that any ordinary traffic might be carried on with regularity and convenience by a single atmospheric line.

Mr. Brunel has proposed to double the line in those places where trains are intended to meet; and he has further shown that in a hilly country, with long planes of sufficient inclination to allow of the descent of trains by the unaided power of gravity, it might be possible to effect this object without the expense of the tube.

With respect to expense, and to some other contested points, your Committee do not feel themselves competent to report a decided opinion. It would scarcely be possible at the present time to institute a fair comparison of a system which has had fifteen years of growth and development, with another which is as yet in its infancy. That comparison would, after all, be very uncertain; it must depend much on details of which we are ignorant; much on scientific knowledge which we do not possess.

There are, however, questions of practical importance, having reference to the present state of the Railway Bills before the House, to which your Committee consider themselves bound to advert.

There is a doubt raised in the reports of the Board of Trade, whether the atmospheric system has been sufficiently tested to justify the preference of a line which can only be worked on the atmospheric system, or which presents gradients less favorable than a competing line for the use of the locomotive engine.

If it were practicable to suspend all railway legislation until the result of the Devon and Cornwall, and of the Epsom and Croydon Atmospheric lines were known, it would be perhaps the most cautious and prudent course to wait that result; but such a course, independent of all considerations of expediency, is evidently impracticable. Your Committee venture, therefore, to express their opinion to the House, that in deciding between competing lines of railway, those which have been set out to suit the atmospheric principle ought not to be considered as open to valid objection merely on account of their having gradients too severe for the locomotive, nor should they be tested in comparison with other lines solely by the degree of their suitableness to the use of the locomotive.

No doubt in matters like these experience alone can decide the ultimate result, but your Committee think that there is ample evidence which would justify the adoption of an atmospheric line at the present time. All the witnesses they have examined concur in its mechanical success. Mr. Bidder says, "I consider the mechanical problem as solved, whether the atmosphere could be made an efficient tractive agent. There can be no question about that; and the apparatus worked, as far as I observed, very well. The only question in my mind was as to the commercial application of it." Mr. Stephenson admits that under certain circumstances of gradients, (1315.) and under certain circumstances of traffic without reference to gradients, (1204,) the atmospheric system would be preferable.

While your Committee have thus expressed a strong opinion in favor of the general merits of the atmospheric principle, they feel that experience can alone determine under what circumstances of traffic or of country the preference to either system should be given.

Railway Mag.

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*First Annual Report of the Directors of the South Carolina Railroad Company, for the year ending December 31st*, 1844.

CHARLESTON, S. C., Feb. 11th, 1845.

The Directors of the South Carolina Railroad Company have the honor to submit herewith their *First* Annual Report, for the year ending on the 31st of December, 1844. Since the last annual meeting at Columbia of the Stockholders of the Louisville, Cincinnati and Charleston Railroad Company, and of the South Carolina Canal and Railroad Company, the consolidation of these two Companies, under an act of the Legislature of South Carolina, bearing date the 19th December, 1843, has been perfected; and all the chartered "Rights, Privileges and Property" of both are now centered in and enjoyed by one corporation, under the name of the South Carolina Railroad Company.

The gross receipts, current expenses, and nett income, on the two Roads, previous to consolidation, for the year 1843, were:

| | | |
|---|---|---|
| From 1st Jan. to 1st July, on Hamburg Road, | | $ 171,241.48 |
| " " " on Columbia Branch, | | 44,740.73 |
| Total, | | 215,982.21 |
| Current Expenses on Hamburg Road, | $103,147.76 | |
| Current Expenses on Columbia Branch, | 20,108.86 | |
| Interest on sterling Bonds and floating note debt, | 59,000.00 | |
| | | 182,256.62 |
| Nett Income, | | 33,725.59 |
| From 1st July to 31st Dec., 1843, on Hamburg Road, | | 177,074.03 |
| " " " " on Columbia Branch, | | 49,835.01 |
| | | 226,904.04 |
| Current Expenses on Hamburg Road, including three Locomotives, | $ 111,673.16 | |
| Current Expenses on Columbia Branch, | 18,437.52 | |
| Interest on sterling Bonds and floating note debt, | 59,000.00 | |
| | | 189,110.68 |
| Nett income, | | $ 37,798.36 |

From which nett incomes the Board of Directors declared, for the first half-year, a dividend of $1 per share; and from the last half-year $1.25 per share, making for the year $2.25 on each share, and equivalent to 3 per cent. on the par value of $75 on the Road stock.

The above statement of expenditures and nett revenue would not seem to accord, on comparison, with the statements made in the report of 1843. In that exhibit, as the Companies had not been consolidated, and the interest on the sterling bonds and floating debt of the Louisville, Cincinnati, and Charleston Railroad Company had been previously provided for out of the funds of that Company, and charged in their books—it was not, and very properly, by the Auditor of the South Carolina Canal and Railroad Company, brought into the account of current expenses paid by him against the Railroad income. As under the head of current expenses, is now correctly embraced all these charges for interest, it was necessary, in a comparative exhibit of expenditures and of nett income for the two years, to embrace interest on bonds and note debt in those for 1843, as they had been embodied in the consolidated Company account for 1844.

The gross receipts, current expenses, and nett income, for the year 1844, on the Roads, as consolidated, were:

| | |
|---|---|
| From 1st January to 1st July, receipts, | $ 244,035.14 |
| Expenses, including one locomotive and extra burden cars, | 185,438.07 |
| Nett income, | 58,597.07 |

| | |
|---|---|
| From 1st July to 1st January, 1845, receipts, | 288,835.81 |
| Expenses, including two locomotives, patents, extra passenger and burden cars, and machinery, | 207,234.24 |
| Nett income, | $ 81,598.57 |

From the above a dividend of $1.50 was declared on each share for the first half year, and $2.25 for the last half year, making $3.75 on each share, and equivalent to 5 per cent. interest on the par cost on each share now represented in the Company. From the exhibit now made, it appears that the gross receipts for the year 1844 exceeded those of 1843 by $89,967.70, and the nett profits by $68,671.69, while the current expenses, for the same period, exceeded those of the previous year by $21,305. This statement goes to confirm, in part, a fact previously brought to the notice of the stockholders, that an increase of business on a railroad does not necessarily involve a corresponding increase of current expenses, where the Company is properly prepared with locomotives, and the requisite number of cars, to meet the business offered. The fixed capital is in the road-bed, and an appropriation or but one-tenth of that amount for an increase of motive power, may more than double or quadruple the capacity of the Company to do the business offered, and at a very inconsiderable augmentation of what may legitimately be charged to current expenses. In the expenditures, however, brought under this head, on the South Carolina Railroad, are included $21,025 for three new locomotives and extra wheels; $17,498 for new passenger and burden cars; $2400 for patents for spark arresters and chilled boxes, and $775 for extra permanent machinery in the work-shops. If from these various appropriations to permanent objects, and amounting in the aggregate to $41,698, be deducted $23,561.50, the amounts expended on similar objects, as shown in the report for 1843, we would have $18,027 to be deducted from $21,305, the excess of current expenditures for 1844, which would reduce that sum to $3278, and show that an increase of 20 per cent, on the gross income of the Road from freight and passengers, involved an increase of but one per cent. on the legitimate current expenditures, and exhibit the encouraging result of 90 per cent. on the nett revenue.

The statements from the Auditor which accompany this report, will exhibit a satisfactory account of the property, the liabilities, and the available assets of the South Carolina Railroad Company, as now consolidated. To the tabular statement, No. 6, the attention of the Stockholders is particularly invited, as exhibiting, on one sheet, a perfect synopsis of the business transactions of the South Carolina Canal and Railroad Company, for each half year from the commencement of operations in the year 1830, to the 1st of January, 1845, including the year 1844, of consolidation with the Louisville, Cincinnati, and Charleston Railroad Company.

This is an interesting paper, exhibiting the number of locomotives in service; the trips and number of miles performed; the income received, and the fluctuations in the trade and travel on the Road, and developing results instructive to those charged with the direction and

management of railways; where *economy* of *expenditure* and *cheapness* of *transportation* are so dependent on the proper construction and judicious application of the powers of the locomotive. This is the great desideratum to be attained in all operations where machinery is used, and of vast importance to railroads, as the element on which their triumph over all other conveyances and success must finally rest. These views cannot be stronger illustrated than by comparing from the table, the operations of the *first* with the last half years of 1843 and 1844. In the first half years, 15 locomotives in service, made 2,036 arrivals and departures; ran over 319,968 miles; transported 130,366 bales of cotton and 48,722 passengers, and realized in money, including the freight on merchandize and the mails, $460,-057.35. In the last halves of the same years 16 locomotives in service, making 1,904 arrivals and departures, and running 304,752 miles; 132 arrivals and departures, and 14,216 miles less than in the first halves of the same years; transported 184,319 bales of cotton, 43,164 passengers, and realized for the Road $515,743.85 in money; shewing that with but one additional engine, and less *miles* and *trips* performed, an increase of 53,953 bales of cotton—a decrease of 5558 in the number of passengers, and an augmentation in the moneyed receipts of $55,686.50. The decrease in the passengers is explained by the facts of two Methodist Camp Meetings in the spring of 1844, at Ladson's Station and the Cypress, and at which it was estimated there were between 5 and 6000 attendants. Another comparison between the years 1842 and 1844, will serve to illustrate the powers and advantages of the larger class of locomotives, six (6) of which have been added the last two years, to the 2d and 3d class engines previously used on the Road. In the year 1842, the year previous to the consolidation of the two Roads, 14 engines in service made 1809 arrivals and departures; performed 286,995 miles; transported 92,336 bales of cotton and 33,925 passengers, and realized in money for the Road $408,704.87.

In 1844, 17 locomotives are returned as having made 1964 arrivals and departures, run over 310,812 miles, and transported 186,638 bales of cotton and 54,146 passengers—and realized on the whole, including freight on merchandise and the mail, $532,869.85, shewing with but three additional engines, an increase of 94,302 bales of cotton, 20,221 of passengers, and $124,164.98 on the gross income, being at the rate of 100 per cent. on produce, 60 per cent. on the number of passengers, and 31 per cent. on the moneyed receipts. The increase on the moneyed receipts does not bear the same proportion to the increase on the quantity of the freight and number of passengers, and which is to be explained by the modification and reduction made on the rates of freight and passage in 1844. In 1842, the fare for passengers was 18 per cent.; on merchandise, from 12½ to 15 per cent.; and on cotton and weight freight, from 30 to 40 per cent. higher than it was in 1844. At the same rate of freights, provided the same amount of business could have been commanded, the increase on the moneyed receipts, on the transportation performed, would have been full 25 per cent. greater.

The subject of the rates for freight and passage on railroads, must be relative, and be governed by the quantity of business and number of passengers offering, and the competition with other common carriers. To meet a competition which is daily increasing from the number of new Roads in the United States, which have been constructed; and from the improvements in, and new application of, machinery, to steam navigation, it will be necessary to be governed in some degree by the fares established by other common carriers, contending for the same business; or forfeit the claim of the South Carolina Road to a fair participation in it. By this policy, in regulating a Tariff for Freight and Passengers, your Directors have been governed; and they will continue, in the future, as they have in the past, to bestow on this, as on all other subjects, affecting the interests of this Company, the consideration of their most matured judgments.

With these Tables, is one shewing the number of Grades and their lengths; with the lengths of the different curves and straight lines; the distance between the different stations and depots, and their relative elevations; with the elevations of each point above tide water; on the road between Branchville and Columbia. A similar table we have in preparation for the Charleston and Hamburg Road, which has not yet been perfected, for the want of the necessary documents.

The Report of Mr. G. B. Lythgoe, the Superintendent of the Road, shews that under his vigilant supervision, the track and embankments have been preserved in the same good condition represented to be in the previous year. He states, however, what has been long since apprehended, that the heads of the piles, sustaining the cross-ties and superstructure, on the Hamburg Road, are beginning to exhibit decay, and to obviate this defect, it will become necessary to lay mud sills on the top of the piles. That, if this work is commenced immediately, its expense may be distributed through consecutive years; and therefore recommends that twenty miles of the road, for the next four years, be so improved, which will probably involve an increased expense for timber and labor, of $300 per month.

On the Columbia road, which is generally in good order, it was found indispensable to renew some of the cross-ties, between Orangeburg and Branchville, the last spring and summer. As it is but four years and six months since that section of the road was finished, that fact goes to confirm the past convictions that the durability of pine timber at the South, exposed as the cross-ties are on the Columbia road, on the surface and but half covered with earth, cannot be depended on to exceed an average of five years; and that all timbered superstructures of roads, in Southern latitudes, will require renewal within that period, or one-fifth each year for the whole extent. By way of experiment, six miles of the Columbia road was constructed of Cypress ties; but sufficient time has not yet elapsed to test their superior durability over pine, or their greater economy in the higher price. The durability of timber is a subject of deep interest to Railroad Companies: particularly as timber superstructures are beginning to claim a preference to those made of materials of a less yielding or elastic character; and has engaged the attention for many years of

the successive Board of Directors of the South Carolina Canal and Railroad Company. The process of kyanizing, which was tested to a small extent, seemed to act favorably on the fibres of the wood to which it was applied; but the problem yet remains unsolved, whether the additional durability imparted is compensated by the extra expense incurred. The experiment with the mineral process, recommended by Dr. Earle, and for which an appropriation was made by the South Carolina Canal and Railroad Company, Mr. Lythgoe thus remarks:—"I regret to say, the process of Earlizing sap timber will not answer the purpose intended: as we are now compelled to take all we have used out of the road as soon as we possibly can, in consequence of its having become so soft and decayed as to allow the iron to embed into it, thereby injuring the iron to a considerable extent." The report of Mr. Lythgoe represents that the expense of the maintenance of way on the Hamburg road the last year, has been $293 per mile; which including the sum of $828 expended in ditching and on embankment, equal to an average of $6 per mile, makes the whole sum $299 per mile. The expense of maintenance of way on the Columbia branch was but $138 per mile, including $424 incurred in ditching and embankments, makes $144.28 per mile. The difference in the expense per mile on the two roads, is explained by the different plan of construction, and the different ages of the roads; the timber, with the exception of one short section, on the Columbia road, not having had time yet to manifest decay or require renewal. The expense of maintenance of way on the Hamburg road, if preserved at the above standard, $299 per mile, is as low, probably, as it can be reduced to; while some addition to the amount incurred for the same objects on the Columbia branch will become necessary, as the age of the road and the business on it increases.

The Report of Mr. Darrel, Master of the Workshops, presents the state and condition of the motive power owned by the Company: and a favorable statement of the quantity of work done in the Finishing and Smith-shops and Foundry, and on the locomotives rebuilding and repairing, the last year. From his report, it appears he received from his predecessor, as Master of the Shops, 23 locomotives of the 2d and 3d class; enumerating all which bore the name in the yard, and one new boiler finished. Of these locomotives, many of which had been in the service of the South Carolina Canal and Railroad Company from its commencement of business in the years '31 and '32, 4 are stated to have been in good order; 7 defective, and somewhat disabled, but performing road service; 6 repairing and rebuilding, and 3 condemned; since which, 3 others of those disabled, have run their career, and been condemned, or laid up in ordinary for summer examination, and see to what profitable purposes they, or parts of them, can be applied. To the above locomotives have been added the last two years, 6 of Baldwin and Whitney's six wheel connected locomotives of the 2d class. Deducting the 6 which have been condemned, or laid up in ordinary, and one (1) that is rebuilding, 22 may be considered as in a condition to be made fit for road duty, under occasional repairs; from 16 to 17 of which have been

kept in active service during the year ending 31st December, 1844, which is a very large proportion. It has been considered good policy, and particularly by those well acquainted with the delicate mechanism of the locomotive, so easily deranged, that Companies should own double the number that they can keep constantly and profitably employed: and the best regulated English and American roads preserve very nearly this proportion. Where the opposite policy is pursued, locomotives often suffer, are soon destroyed, and rendered worthless, from the want of timely and effectual reparation. When the business of the road presses, and in no modes of transportation are the alternations from one extreme to the other so frequent as on railways, temporary expedients, where there is a deficiency for the time of power, must be resorted to; and engines, though slightly disabled and easily repaired, are too frequently forced, from necessity, on another trip, to their more permanent injury, if not ruin; or taken in shop late at night, hastily overhauled, and rudely repaired by the light of the torch, so as to be replaced on the road, for service, in time next morning. It is difficult, under such arrangements, to preserve the locomotives in the best condition for profitable use; or to conduct the operations at the workshops, and regulate the transportation on the road with economy and satisfaction.

The Joint Report of the General Agent, Mr. King, and the Agent of Transportation, Mr. Hacker, show that this Company now have in service, for the very large and increased business which has devolved on it, but 18 passenger and baggage cars, and 283 freight cars; 147 of which are of four wheels, with canvass sides, and of inconsiderable burden: the whole of them not more than equal to accommodate the loads for two engines. Of these, one 8 wheel passenger, one 8 wheel baggage, thirty-two 8 wheel box, and fourteen 8 wheel platform cars, have been added during the year 1844, and at a cost to the company for wood work of $7020, and for wheels and axles, as reported by Master of Workshops, $10,478—making for the whole, $17,498. Both of these officers, and whose duties and responsibilities afford them the best opportunity of forming correct opinions, concur in the necessity of an additional number of passenger, baggage, and burden cars, to do the business of the road to the best advantage, with punctuality, and to the satisfaction of travelers and shippers. The want of more suitable and more enlarged accommodations at the depots at Charleston, Hamburg and Columbia, is the more strongly enforced by their testimony; and while these subjects have engaged the attention of the Board of Directors, whose term of service now expires, they cannot too strongly impress its importance on those who, by your selection, may be their successors in office for the present year. It may involve considerable expenditure in the first instance; but the interests of the Company and its security and protection from probable heavy loss, and its ability, through active agents, to discharge with exactness and despatch its varied responsibilities, as a common carrier, to all who travel and transport on the road, strongly recommend the necessity of more suitable, more commodious, and more permanent buildings, at the workshops, and

the three important depots at Charleston, Hamburg, and Columbia, than at present exist.

At the last Session of the Legislature, application was made by many of the citizens of Sumter and Kershaw, for aid in the form of a subscription, to assist in extending the South Carolina Railroad, under a provision in its charter, to Camden. That body declined participating in the enterprise as a Stockholder, but responded favorably to the application, so far as to authorize this Company to become Joint Stockholders with the citizens of that section of country through which the road to Camden was to pass, and as a motive for this Company so to co-operate in the work, an act was passed authorizing the funding, at five per cent. interest, and on time, of a debt which accrued under the law reducing the stock in the Louisville, Cincinnati, and Charleston Railroad Company, and which now stands to the credit of the State in the books of said Company. A reference to the act will explain more satisfactorily its provisions. To enable the Stockholders to act more advisedly on the subject, and at the particular solicitation of many of the citizens of Sumter and Kershaw, who had expressed an interest in the enterprise, a preliminary survey was ordered by the Board of Directors. Mr. Mac Rae, favorably known to the Stockholders, was charged with the service, and his report and approximate estimate of the probable cost of the work, is herewith respectfully submitted. His estimate is based on two plans of superstructure. In the one, where a wooden stringer and light iron rail is used, the cost is estimated at $450,000. In the other, where a heavier T rail is used, and the plan is made to conform to that of the Columbia road, the cost is put down at $540,696. In both estimates the present specific duty on rail iron at $25 a ton is included—amounting to $60,000 on the first, and $90,000 on the last estimate. If the tax is remitted, or reduced to a revenue standard, there will be a corresponding decrease in the probable cost of the road.

The Board of Directors, with much satisfaction, now report to the Stockholders, the extension of the Georgia Railroad to Covington, twenty-five miles beyond its late terminus at Madison; and that the reported progress in the section above, removes all doubts as to the road being completed to Whitehall, the point of junction with the Western and Atlantic Railroad, by September or October next, and in time for the opening of the fall business. At the same period, such is the progress now making with the work on the Western and Atlantic Railroad, that that road will be completed and in operation to the Oostanauly, eighty-four miles beyond Whitehall, and within fifty-six miles of the Tennessee river, at Chatanouga, and seventeen of the Coosa, at Rome.

Within the last twelve months the condition of the West Point and Montgomery Railroad has been greatly improved, and active measures taken to extend it some five or six miles east of Chehaw. At the late session of the Legislature of Alabama, the 2 per cent. land fund, amounting to about $240,000, was appropriated in equal proportions, and on most favorable terms, to the completion of the West Point and Montgomery road to the Chattahoochee, and to that of a

newly projected road connecting the Coosa, by Will's Creek Valley and the Sand Mountain, with Gunter's Landing on the Tennessee. All these events go to approve the late action and policy of a majority of your Board of Directors in co-operating to the extent of their ability with the Georgia Railroad and Banking Company, and the West Point and Montgomery Railroad Company, for the completion of their respective enterprises, estimating them as important links, in the great chain of railroad intercommunication connecting the extreme Eastern with the most South-western extremities of the Union —an enterprise in which not only this Company, but the City of Charleston and State of South Carolina, cannot but feel the deepest interest, and acknowledge the important influence its completion must have on the prosperity of each.

All of which is respectfully submitted by

JAMES GADSDEN, *President.*

**To be Continued.**

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## *Uniformity of Gage.*

No man can doubt the desirableness of one uniform gage, if at any reasonable cost it could be attained. Mr. Cobden has, therefore, done wisely in bringing it forward, even now late as it is.

Great difference of opinion existed at first among engineers as to what should be the proper gage. Most of them were of opinion that the present is too narrow, and perhaps if the whole was to be done over again, we should have it something wider.

The reasons for a wider gage were chiefly two—one, that the present gage would be dangerous at high speeds, and the other, that it did not afford scope for that powerful machinery in locomotives necessary for attaining very high velocities. Greater research and experience have exploded the first, and along with it, one of the arguments of Mr. Brunel for his broad gage. He asserted, that by increasing the gage he should be able to use higher wheels on the carriages and engines, and that these higher wheels on the carriages would work with less friction, and, therefore, more economy. The less friction with high wheels, we at first opposed, as being contrary to the results of experiment, which showed that slipping friction is independent of velocity, and the rolling friction on railways is insignificant; and experience has taught Mr. Brunel that we were right, for he has abandoned his high wheels for carriages.

In respect of the engines, this fact is enough. There are, or were, about his Company's premises, engines with ten feet wheels, which cost some £30,000 or £40,000, and have never been used, for one very good and—to all other men's minds except Mr. Brunel's, until he tried them—very obvious reason, namely, that they did not possess the power to work. They are, of course, laid aside, and the Company have gradually come down to more reasonable dimensions, we believe from six or six and a half to seven feet wheels.

The second reason, that is, that the narrow gage does not afford room for machinery competent to compass high velocities, was no

doubt good at the time, but by a better arrangement and larger boilers, Stephenson has got over the difficulty.

To understand this point, the reader should be informed, that the power of an engine to draw great loads at moderate velocities, and small loads at high velocities, depends on two very different qualities. One is the weight of the engine combined with cylinders large enough to use it, and a boiler to supply steam moderately fast. Hence, heavy engines, with coupled wheels, are generally required to exhaust all the weight of the engine. The other depends not so much on the weight of the engine—which is seldom if ever taxed to the full or a fourth—as on the power of the boiler to generate steam rapidly. This, Mr. Stephenson's new engine, combined with an expansive apparatus, does effectually, and appears, by an improvement lately introduced of double valves one above the other, with an advance of eccentric to close the parts earlier, to be capable of still greater improvement. In these engines, it is not great statical power, but an abundant supply, and a proper husbanding, of steam, that are wanting. In short, for heavy loads weight of engine is the principal element, but for high speeds, a rapid supply of steam. This, at first, Brunel maintained could only be accomplished by more room for the boiler, that is, by a wider gage. Mr. Robert Stephenson, however, has cut this reason away, by increasing the length of the boiler, and generating more steam with the same fuel. The simplification which he at the same time gave to the working gear, and the improvements which have lately been made in the valves, have at length furnished us with the means of economizing this steam so much as, in fact, to give us much more than we want.

Both Brunel's reasons, therefore, for the broad gage, whatever plausibility they had in the first instance, now no longer exist.

If, then, there be any change of gage, reason tells us that it should be from the broad to the narrow gage. Not only is it the gage containing some four or five times the number of miles in operation, but the change could be made at incomparably less cost, and without any danger to the public or delay in the traffic. Another rail within each of the outer rails would do it as far as the road is concerned; for which the road is prepared, and only wants the rails to be laid down. The cost would be under £80,000. In a month or less after the materials are procured, the whole may be done with a proper force. All the tunnels, all the cuttings, bridges and embankments, which do for the broad gage, will equally do for the narrow. But, as it was well observed in the House, and is stated by one of our correspondents, if the converse is to be done—the narrow turned into the broad—the whole works must be changed. More land must be bought; the bridges, tunnels, embankments and cuttings, must all be widened. At a moderate estimate, the cost of the change would be from a fourth to a third of the entire cost of the line. Twenty millions would not do it; and as to the time required, no one could calculate it. Of the danger, too, attending widening tunnels, we have had a specimen by the falling in of the tunnel while it was widening on the Newcas-

tle and Carlisle Railway. To talk of changing the narrow to the broad gage, would be very little short of insanity.

That a change would be desirable to one uniform gage is too evident for discussion. We can only say that we shall be glad to see it for the convenience of the public principally, but also to prevent these unseemly strifes which we have lately witnessed between the two gages; and we wish, therefore, every success to Mr. Cobden's motion on Wednesday evening, which we are glad to see was well received by the House.

A Commission is to be appointed for the purpose. We only hope it will be a judicious one. Railway Mag.

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### *Projected Railways before Parliament.*

A very curious return has just been laid before Parliament, in relation to projected railways now before Parliament. It thence appears that the railways, of which plans and sections have been deposited with the Railway Department of the Board of Trade, amount, in length, for Great Britain and Ireland, to no less than 8080 miles, being thus nearly 24 times the length of England itself! The following are the proportions of the lines proposed to be made in the different countries of the United Kingdom: England has, as her share of these projected railways, 6086 miles and a fraction; Scotland has about $\frac{1}{10}$ the quantity—the proposed lines in that country only extending to 595 miles; Ireland, however, is far ahead of Caledonia in this respect, and the sister isle has no fewer than 1401 miles of railway projected to be laid down therein. These statements have regard only to the projected lines which are this session before Parliament for consideration. They do not include any portion of the numerous lines that have since and are weekly, or rather daily, being brought forward, but merely give the length of the railways, plans for which were deposited with the Board of Trade towards the close of last year, in accordance with the directions issued by the Railway Department of that Board. Globe.

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### *Labor Provided by Railways.*

That some idea may be formed of the immense stimulus the trade of the country would derive from the formation of the contemplated railways, it is only necessary to state that were 2000 miles of the projected railways to be constructed, it would give employment to 500,000 laborers and 40,000 horses for the next four years.

Railway Mag.

## ENGLISH PATENTS.

*Specification of a Patent granted to* ALEXANDER EWING, *of the county of Dumbarton, Scotland, for certain improvements in the manufacture of crown-glass.* [Sealed 15th August, 1844.]

In the ordinary mode of manufacturing crown-glass, the metal is liable to be unequal in substance from rim to rim, or in particular places; to produce greater equality of thickness or substance in the tables of crown-glass, is the object of this invention.

The improvements come into operation when the workman, called the gatherer, has formed the piece of glass, or metal, on the "hand-pointing, or gatherer's, marver," and when the piece, so formed, is about to be perforated by the blower behind, or during the operation of perforating, or immediately after it. At this stage of the process, the gatherer is to apply that part of the gathering which is near the tube, or pipe, to the implement, *a*, made of iron, or other metal, (termed a cutter, and represented at fig. 1,) bolted to the standard, *b*,

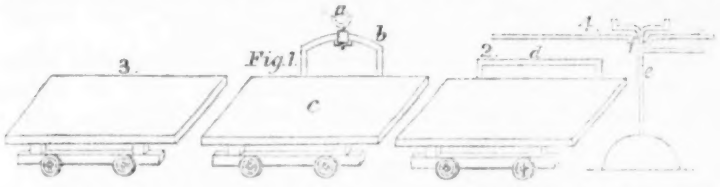

Fig. 1.

at the back of the gatherer's marver, *c*; and then the piece being turned round, an incision is made by the implement, which displaces the metal from the nose of the pipe into the shoulder of the gathering, insuring strong shoulders: the rim may be thus brought to any consistence; and, after expansion, an equality of substance of the table, generally, will be the result: and, owing to such uniformity, a more effectual standing in the annealing arches can be depended upon. The patentee does not confine himself to the form of the implement, *a*; he sometimes employs, instead of it, a circular bar of iron, or other metal, *d*, fig. 2, attached to the marver; and sometimes he uses the edge of the common marver, fig. 3, for producing the same effect.

At the time of perforation, or before, or immediately after that operation, the glass is carried, as usual, to the "pattison hole," and, a heat being taken, it is marvered on the blower's marver; it is then returned to the pattison hole, and, when sufficiently heated, is taken by the workman to the stake, or standard, *e*, fig. 4, in order to increase the size of the globe. To the upper part of the standard, *e*, a cutter, *f*, is secured, by a nut and screw, in such a manner as to admit of its being raised or lowered at pleasure: and this cutter is applied to the nose, or neck, of the piece, to prevent it from swelling at the nose, and to effect a greater disunion of the piece from the pipe. The piece is then taken to the "bottoming hole," by the blower, and heated, and blown to the size desired; after which it is taken to the

"casher-box;" then to the "nose-hole;" and lastly to the annealing arch, or kiln."

The patentee does not confine himself to the details of the apparatus used, as above described; provided the peculiar character of the invention be retained. He claims, Firstly,—the mode of operating in the manufacture of crown-glass described in respect to fig 1. Secondly,—the mode of operating in the manufacture of crown-glass described in respect to fig. 4.—*Inrolled February*, 1845.

Lond. Jour. Arts and Sci.

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*Specification of a Patent granted to* Thomas Heaton, *county of Lancaster, for his invention of certain improvements in hydraulic machinery, which are also applicable to raising other liquids.*—[Sealed 15th August, 1844.]

This invention applies particularly to hydraulic machinery, such as pumps or engines, employed for raising or forcing water from mines, pits, &c.; but it is equally applicable, in principle, to manufacturing and domestic purposes, and especially for ships' uses, fire-extinguishing engines, and similar purposes, where water or other fluids are required to be displaced.

The first feature of novelty consists in the application of a hollow ram, or plunger, which may be of an equal area with the working barrel, either more or less, engaged either in connexion with a common, or the improved, bucket, hereafter described, in place of the ordinary pump-rod, or connecting-rod. This application of a hollow ram, or plunger, to pumps, or other hydraulic machinery, for raising and forcing water and other fluids, is for the purpose of displacing a considerable quantity of the volume of fluid above the bucket, as the bucket descends; and by thus removing the weight of fluid above the bucket, greatly economizing the power required, and reducing the strain upon the working machinery of the primary moving power. It will also be evident, that as the object of this ram is to displace a large quantity of water, a wooden ram, of a similar diameter, might be adapted in lieu thereof.

Secondly,—these improvements in hydraulic machinery consist in the novel application, or employment, of a double set of valves to the clacks and buckets of pumps, for certain useful purposes hereafter described. And thirdly,—the invention consists in a particular method of packing either the bucket, the working-barrel, or other parts of pumps, by the novel application of a material now well known as "Jeffery's marine glue;" the use of which for such purposes is particularly advantageous, whether it be employed alone, or combined with filings of brass or other metal, layers of leather, or other substances.

Fig. 1 represents a sectional elevation of the working parts of a pump, in connexion with pump-trees, above and below, and supposed to be employed for raising water from a mine, well, cistern, or other reservoir; fig. 2 is a similar sectional view, but exhibiting some modifications in the internal arrangement; fig. 3 is a transverse section, taken through the pump, at the line A, B, in fig. 1, showing a plan view of the top pair of valves of the bucket and the stuffing box; and

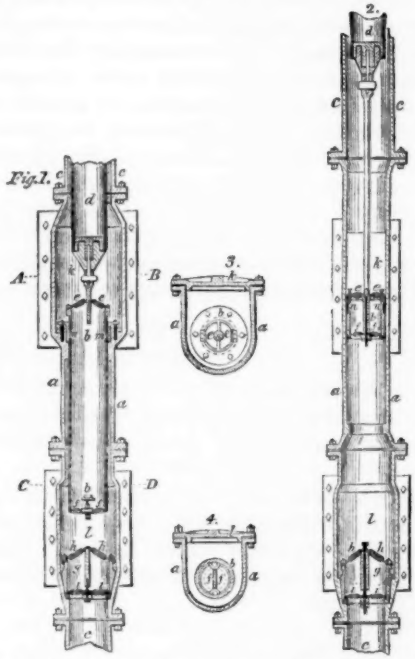


fig. 4 is a similar view, taken through the line C, D, shewing the bottom pair of valves of the bucket. *a*, *a*, is the working-barrel of the pump; *b*, *b*, the bucket; and *c*, *c*, *c*, the pump-trees, extending upwards and downwards from the working-barrel; *d*, *d*, is the hollow ram, which extends upwards from the bucket, (in place of the ordinary connecting-rod) to the top of the pump-trees; the upper end of this ram being closed, a cylindrical air-vessel, occupying a very considerable portion of the area above the bucket, is formed, and a corresponding volume and weight of fluid is consequently displaced. It will be observed, that the bucket, *b*, *b*, is furnished with two sets of valves, or bucket-lids, *e*, *e*, and *f*, *f*, so that, should one of the valves be prevented from closing by a piece of wood, a stone, or any other substance, (which is very liable to be the case in working from a bad bottom,) the other valve may close, and raise the water, while the down stroke of the bucket will be sure to clear away the impediment. The clack-piece, *g*, *g*, is also furnished with two sets of valves, or lids, *h*, *h*, and *i*, *i*, for the same purpose; which clack and bucket-lids

may either be hung upon hinges, as shewn in the drawing, or be made to rise and fall separately upon spindles or slides. It will be observed, that doors or plates are provided, for the purpose of readily obtaining access to both the buckets and the clacks; thus admitting of their being cleaned or put in order, as occasion may require. *k*, *k*, are the bucket-doors, and *l*, *l*, the clack-doors.

The peculiar method of packing hydraulic machinery is represented in two separate modifications, at figs. 1 and 2; that in the former being enclosed by a glandular ring, in the concentric groove, *m*, *m*, *m*, (the pump-barrel thus completely surrounding the bucket, which, in this case, is lengthened, to allow of such mode of packing;) and that in fig. 2 being shewn in a reverse position, or placed in the groove, *n*, *n*, turned in the bucket, and thus forming the packing between it and the working-barrel. In both instances the spaces between the grooves, *m* and *n*, are to be tightly packed, either in the common way or with "Jeffery's marine glue." This composition, the patentee states, will be found most efficient for such purposes; it consists of caoutchouc dissolved in conjunction with shellac, and is highly elastic, and quite impervious to the passage of water.—[*Inrolled February*, 1845.]

Ibid.

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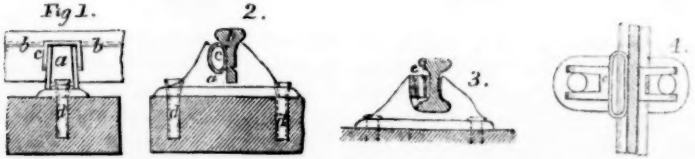
*Specification of a Patent granted to* William Henry Barlow, *of Leicester, for improvements in the construction of keys, wedges, or fastenings, for engineering purposes.*—[Sealed 6th March, 1844.]

The novelty of this invention consists in substituting, in place of solid metal, or wooden, wedges, or keys, now employed for engineering purposes, a peculiar construction of fastening, made of hollow metal, by which means a degree of elasticity is obtained, together with lightness and strength.

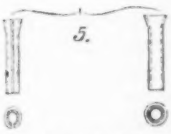



Figs. 1 and 2 are front and end views of a railway chair, shewing the rail fixed in its seat by means of the hollow wedge. *a*, is the chair; *b*, the rail; and *c*, the hollow wedge (made of wrought iron) which is driven between the rail and the chair. This wedge is made into a perfect tube, by welding its parallel edges together, and, if thought necessary, one side of the tube may be flattened to fit the side of the rail. The patentee, although he prefers the wedges, or keys, to be welded, (a less thickness of metal being in that case required to give the necessary strength and elasticity,) states that they may be employed without welding, but that the edges should abut against each other.

Another mode of constructing hollow wedges, or keys, for securing

the rails of railways, is shewn at *c*, figs. 3 and 4: the wedge in this case is similar to a link of a chain.

Hollow wedges formed like a tube are also employed for securing the chairs to their sleepers, as represented at *d*, *d*, figs. 1 and 2: tubes, either welded or not, may be used for this purpose, as shewn at fig. 5. The patentee states that, although he has shewn the exact form of wedges, keys, or fastenings, which he has used, he does not confine himself to these particular forms; but he claims the mode of making keys, wedges, or fastenings, for securing railway bars in the chairs, and securing railway chairs to the sleepers, or blocks, and for other engineering purposes, by forming them of hollow metal, as above described.—[*Inrolled September*, 1844.]




Ibid.

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*Specification of a Patent granted to* Frederick Ransome, *of Ipswich, for improvements in the manufacture of artificial stone for grinding and other purposes.*—[Sealed 22d October, 1844.]

This invention consists, firstly, in manufacturing artificial stone, by cementing broken or pulverized stone, sand, or earthy or metallic matters, with a solution of silica; and secondly, in subjecting the artificial stone, formed in this manner, to hydraulic or other mechanical pressure, in moulds.

The solution of silica, or siliceous cement, is made, by preference, in the following manner; but the patentee does not confine himself to this mode of preparing it:—100 lbs. of crystalized carbonate of soda are dissolved in 50 gallons of water, and the soda is rendered caustic by the addition of lime; or, instead of carbonate of soda, 50 lbs. of carbonate of potash are dissolved in the requisite quantity of water, and the potash rendered caustic, as above mentioned. The caustic alkaline solution is reduced, by heat, to 20 or 25 gallons; it is then put into an iron boiler, or digester, with 100 lbs. of finely broken flints, or other siliceous substance, and the mixture is heated, during ten or twelve hours, up to a pressure of about 60 lbs. to the square inch, (being frequently stirred during that period;) after which it is removed from the digester, and passed through a sieve, to separate any undissolved stone from it. The cement is now ready for use; or may be brought to any required consistence by the admixture of sand, or finely powdered flints; or it may be thinned by the addition of water.

Mill-stones are made, according to this invention, by mixing together one part of siliceous cement, one part of powdered flint, or powdered pipe-clay, and three or four parts of fragments of burr, or other suitable stone; this compound is subjected to mechanical pressure, in iron moulds, and, after being removed therefrom, is allowed to dry, at the ordinary temperature of the atmosphere, for twenty-four hours; it is then placed in an oven, or drying-room, where the temperature is gradually raised to that of boiling water, and the stone

is thus effectually dried. When artificial stone, for other purposes, is to be manufactured, a mixture is made of granite, common sand, or fragments of any siliceous or other hard stone or substance, with from one-fourth to one-sixth of the siliceous cement; and it is treated in the same way as that above described.

By reducing the stone or other material to very fine particles, previous to adding the siliceous cement thereto, more or less fluid mixtures may be produced, for coating walls or other surfaces.

The patentee claims, Firstly, the mode of manufacturing artificial stone, for grinding or other purposes, by cementing broken or pulverized stone, sand, or earthy or metallic matters, with a solution of silica. And, Secondly, subjecting artificial stone, produced by the aid of a solution of silica with broken or pulverized stone, sand, or earthy or metallic matters, to hydraulic or other mechanical pressure, in moulds.—[*Inrolled April*, 1845.] Ibid.

## MECHANICS, PHYSICS, AND CHEMISTRY.

### *On the Construction and Proper Proportions of Boilers for the Generation of Steam.* *By* Andrew Murray, Assoc. Inst. C. E.

(Read at a meeting of the Institution of Civil Engineers.)

This paper commences by investigating the quantity of air chemically required for the perfect combustion of a given quantity of coal, of the quality commonly used for steam purposes. The amount of air to each pound of coal is stated to be 150.35 cubic feet, of which 44.64 cubic feet are required for the various carburetted hydrogen gases given off, and 105.71 for the solid carbon. The practical utility, however, of this knowledge, is much impaired by the circumstance that combustion ceases even in pure oxygen, and much more in air, before the whole of the oxygen present has entered into the new chemical combinations required. It is also known, that carbonic acid gas exerts a positive influence in checking combustion, as a candle will not burn in a mixture composed of four measures of air and one measure of carbonic acid gas. Large quantities of this gas being generated by the combustion of the solid carbon on the grate, and being necessarily mechanically mixed with the inflammable gases as they rise, the quantity of air required for their subsequent combustion must, on this account, be increased to a very large extent. The whole of the air thus supplied in excess, must be heated to a very high temperature, before any combustion can take place, and the loss of the heat thus absorbed must be taken into account in calculating the ultimate economy of igniting these gases.

The form of furnace now in general use, in which the fuel is spread over a large surface of fire-bar, has not been subject, in so far as effects the supply of air through the bars, to much alteration, amongst the many patents and proposals which have been made for the more complete combustion of coal. The point most open to change in the common furnace, is the width between the bars; and as it is desira-

ble to have the supply of air to the furnace as abundant as possible, it should be made as large as can be done without causing waste, by allowing the coal to fall through into the ash-pit. A greater number of thin bars is thus to be preferred to a smaller number of broad or thick bars; indeed, to such an extent is this carried in France, where coal is more valuable than in this country, and the chemistry of the subject perhaps more generally understood, that the bars are made not more than half an inch thick, the necessary strength being obtained by making them four inches deep. With coke or wood, which cannot fall through the bars and be wasted, in the same way as coal, the space is always made much wider, and with great advantage; so much so with coke, as to have led to the opinion that a given quantity of coke would produce as much heat by its combustion as the coal from which it was made. Any grounds for such an opinion could only have arisen from the combustion of the coal having been so imperfect, that not only had the whole of the gases passed off unconsumed, but even a large portion of the solid carbon must have been allowed to escape in the form of carbonic oxide, without having generated its due amount of heat, and been converted into carbonic acid gas.

In the combustion of coke, or of the solid portion of coal, as left in an incandescent state on the fire-bars of a common furnace, after the volatile gases have passed off, the amount of heat generated by the whole of the carbon, uniting at once with its full amount of oxygen, will be the same as what would be generated by its combination, first, with a smaller quantity of oxygen, forming carbonic oxide; and subsequently, by the ignition of this gas, by its combination with the further quantity of oxygen required to turn it into carbonic acid gas.

As some portion of the carbon is always converted into carbonic acid gas in the furnace, it follows, that the air for the ignition of any carbonic acid there formed, and allowed to pass into the flues, must be greatly in excess of the quantity chemically required; and the whole of this excess must be raised to the temperature of the other gases, with which it will be mingled. The superior economy, therefore, of at once converting the whole of the carbon into carbonic acid gas, is apparent; and there is no doubt but that this very desirable result may be obtained nearly to the full extent, by due care in the formation and subsequent management of the furnace.

The best mode of supplying air to the other inflammable gases resulting from the combustion of bituminous coal, which are composed of hydrogen and carbon, and which will be treated of under the common name of carburetted hydrogen, has been a matter of much controversy, and been the subject of many patents. The mode proposed by the greater number of the patentees is, to admit the air immediately behind the furnace, at the back of what is termed the bridge. A bridge does not exist in every case; but where it does exist, it is generally in the form of a wall or obstruction right across the back of the furnace; often placed there for notother purpose than to prevent the fire from being pushed back into the flue. The whole

of the products of combustion, as formed in the furnace, necessarily pass over this bridge, before entering the flue. The additional air is sometimes heated, previously to its being admitted to the gases, after they have left the furnace, and the manner in which it is supplied varies exceedingly; one party advocating its admission in a long thin film, another through a great number of small orifices, and others again attach less importance to the manner of its admission, so that it is only admitted in sufficient quantity. All these plans proceed upon the supposition that large quantities of inflammable gas pass off from the furnace, and as none of them directly affect the operations going on within the furnace itself, the gases which are actually given off would be the same until they pass over the bridge, whichever plan might be adopted.

These plans must all cease to be necessary or useful, if a furnace can be so constructed, and the combustion of the coal in it so managed, that a very small proportion only of uncombined inflammable gases would pass off, as in this case no economy would result from their combustion, owing to the large excess of air which must be supplied and heated as before explained.

The admission of a large quantity of air into the flue, at a distance from the furnace, though advocated by some authorities, cannot be advantageous, unless in extreme cases, when the temperature in the flue is very high, and where the combustion in the furnace has been more than usually imperfect.

As the carburetted hydrogen gases are generated rapidly, on the application of heat to the coal, and are in themselves much lighter than the carbonic acid gas, or the nitrogen gas, formed at the same time, it is sometimes assumed that they rise nearly unmixed to the top of the space over the furnace, and thence it is considered more advantageous to supply the air at this place than in the flue. The cooling effect of air, if admitted into the furnace, has been stated to be more injurious than if admitted into the flue; but the correctness of this statement may be doubted, especially if the gases be unmixed, as this would render a much less quantity of air sufficient.

The bars in this case should be placed at least two and a half feet or three feet below the boiler, or the crown of the furnace, to allow the principle to be more fully carried out. An increase of space over the bars to this extent has always been found to be advantageous, and ought to be particularly attended to. The system of admitting the air to the gases in a subdivided form, in whatever part of the boiler the admission of it may take place, is very efficacious in procuring a thorough and speedy mixture of the particles. It has been very extensively and successfully introduced by Mr. C. W. Williams in supplying air behind the bridge of the furnace.

An opinion is entertained that a sufficient supply of air for the gases may be obtained through the fire-bars; and it is obvious that a partial supply, at least, may be obtained in this manner, by a judicious management of the fire. This may be effected by keeping the fires thin and open, feeding by small quantities at a time, or by a system of coking the coal, allowing the combustion of it to be slow at first,

by which means the coal is formed into masses of coke, between which the air has a passage. The air which passes through is not vitiated further than in being mechanically mixed with the carbonic acid and nitrogen gases, caused by the combustion of the coal on the bars.

The perfect combustion of the whole ingredients of coal being entirely dependent, chemically considered, on the supply of the due quantity of atmospheric air, it is evident that the velocity with which the air flows into the fire will materially affect the result. According as this velocity is greater or less, so in proportion must the quantity of coal that is to be consumed on a given area of grate be increased or diminished, and there is no limit to the quantity that may be so consumed, beyond the difficulty of supplying the air sufficiently rapid. The various circumstances which affect the velocity of the entering air, have placed this question, as yet, completely beyond the reach of theory, so that practical experiments must be taken as the only guide, in determining what quantity of air can be made to enter into a given furnace, and, consequently, what amount of coal can be properly consumed in a given time.

Mr. Parkes has stated, as the result of a long series of experiments made by him, (vide Trans. Inst. C. E., vol. iii.,) that the rate of combustion should not exceed seven pounds per superficial foot of grate bar per hour, and that this quantity may with advantage be reduced as low as four pounds, or even three pounds. General experience would tend to prove that these latter quantities are unnecessarily low, and can only be advantageous when the arrangements for supplying the air, or for carrying off the products of combustion, are defective or inefficient. It is evident that if the area of any part of the passage, for either of these currents, be too limited, the velocity at this contracted spot cannot rise higher than is due to the weight of the ascending column of heated gases in the chimney. The quantity passing through is therefore diminished in proportion as the area is limited; and a good draught at a particular place, as at the bridge of a boiler, may here be quite compatible with an insufficient supply of air, and imperfect combustion of the coal. The draught in every other part of the flues is, at the same time, rendered slow and languid, and deposition of soot takes place in them. This fault is apparent in a great number of boilers at present in use, and in some cases, especially in tubular boilers, it is attended with very injurious results, by stopping up the tubes, and decreasing the amount of heating surface to such an extent, as to render the boilers incapable of generating the required amount of steam.

The furnaces of the boilers in general use in Cornwall, are upon the common principle of construction, and as in them it is not usual to apply any of the peculiar patented arrangements for the supply of air to the gases, behind the bridge, it follows, either that these gases are not consumed, or that they are consumed by air admitted through the bars. In the Cornish system of raising steam, slow combustion is adopted in its fullest extent; the fires are kept thin and open, the fuel is supplied in small quantities and frequently, and it is well

spread over the whole surface. As the result is highly favorable in the economy of fuel, it may be presumed that the combustion of the gases, as well as of the solid carbon, is comparatively perfect. When more air is admitted into the furnace than can be made to enter through the bars, it is generally done by apertures in the furnace doors.

The average rate of combustion throughout the country is far above even the largest quantity named by Mr. Parkes, and may be stated to be about thirteen pounds per superficial foot of grate per hour. With due care in the construction of the furnaces and flues, there seems to be no reason why this quantity may not be as perfectly consumed, and the heat as thoroughly extracted from the products of combustion, before they leave the boiler, as with the smaller quantity. Whether this be so or not, it is necessary in practice to prepare for many cases, as on board of steam-vessels, where it is impossible to allow a larger amount of fire grate, or boiler room, and when it would cease to be ultimately economical to obtain a small saving of fuel, by great additional expense in boilers and their fittings, and in space for them.

To determine the velocity with which the products of combustion pass off from the furnace, or from the boiler, is attended with much difficulty, on account of the great number of extraneous circumstances which do so easily and so constantly affect it. Some experiments on this subject were made by Dr. Ure, and an account of them was read before the Royal Society, (read June 16, 1836,) when he stated, that he considered the velocity might be taken at about thirty-six feet per second, and as this result has been corroborated by others, it may be assumed, in the absence of better data, as nearly correct.

The subject, in a theoretical point of view, is surrounded by many difficulties—in discovering the allowance which must be made for friction, and other circumstances, similar to those affecting the flow of water through pipes; and though this latter has engaged much more of the attention of scientific men, no very definite results, to bear accurately upon practice, can yet, even in this case, be obtained by calculation.

The practical question of the proper proportions of the different parts of boilers is then proceeded with in the paper, the leading chemical and physical features connected with the combustion of coal in their furnaces having been considered.

The supply of the requisite quantity of air to the fuel on the bars being of the utmost importance, it is usual to make the ash-pit, and the entrance to it, as large and as free as the situation will allow. In marine boilers, or wherever it is necessary to limit the size of the ash-pit, the area for the entrance of the air into it should never be less than one-fourth part of the area of the grate; and in order to facilitate the supply to the back part of the grate, the bars should be made to incline downwards to the extent of about one inch in a foot. No advantageous results will be obtained from increasing the ash-pit, as is sometimes done in land boilers to a very great extent, by making it five or six feet deep; about two and a half feet is sufficiently deep,

even supposing that the ashes are not cleared out oftener than once a day.

The extent of "dead plate" in front of the furnace is not material, as respects combustion; in marine boilers it is generally not more than about six inches broad, which is the width of the water space between the fire and the front of the boiler; but in land boilers it is frequently required to be very broad, to support the brickwork, especially in those cases where the flue is carried across the front.

The amount of the opening between the bars should be about seven-sixteenths of an inch, but this must be regulated by the kind of coal to be burnt upon them; but for any kind of coal, it should not be less than three-eighths of an inch, nor more than half an inch. If the space were made larger, the waste from the amount of cinders, or of small pieces of coke, which would fall through in a state of incandescence, would be considerable; otherwise it would be preferable to have a larger space. In order to facilitate the supply of air, each bar should be as thin as is consistent with the strength required. The bars in general use in this country are one inch or one and one-eighth inch in thickness, but it would be much more advantageous to use them thinner, as in France, where they are frequently used not more than half an inch thick.

The advantage of a considerable amount of space in the furnace, over the fire-bars, has been already mentioned, but no very decisive experiments have been made on this subject. Three cubic feet of space to each superficial foot of grate bar surface, may be stated as a good proportion, where there is nothing to prevent this amount being obtained. When the space is reduced below one foot and a half of grate, it will be found to be attended with a marked disadvantage.

The area of the flue, and subsequently of the chimney, through which the products of combustion must pass off, must be regulated by their bulk and their velocity. The quantity of air chemically required for the combustion of one pound of coal, has been shown to be 150.35 cubic feet, of which 44.64 enter into combination with the gases, and 105.71 with the solid portion of the coal. From the chemical changes which take place in the combination of the hydrogen with oxygen, the bulk of the products is found to be to the bulk of the atmospheric air required to furnish the oxygen, as 10 is to 11. The amount is therefore 49.104. This is without taking into account the augmentation of the bulk, due to increase of the temperature. In the combination which takes place between the carbon and the oxygen, the resultant gases (carbonic acid gas and nitrogen gas) are of exactly the same bulk as the amount of air, that is, 105.71 cubic feet, exclusive, as before, of the augmentation of bulk from the increase of temperature. The total amount of the products of combustion in a cool state would therefore be $49.104 + 105.71 = 154.814$ cubic feet.

The general temperature of a furnace has not been very satisfactorily ascertained, but it may be stated at about 1000° Fah., and at this temperature the products of combustion would be increased, according to the laws of the expansion of aëriform bodies, to about

three times their original bulk. The bulk, therefore, of the products of combustion which must pass off, must be $154.814 \times 3 = 464.442$ cubic feet. At a velocity of 36 feet per second, the area, to allow this quantity to pass off in an hour, is .516 square inch. In a furnace in which 13 lbs. of coal are burnt on a square foot of grate per hour, the area to every foot of grate would be $.516 \times 13 = 6.709$ square inches; and the proportion to each foot of grate, if the rate of combustion be higher or lower than 13 lbs., may be found in the same way. This area having been obtained, on the supposition that no more air is admitted than the quantity chemically required, and that the combustion is complete and perfect in the furnace, it is evident that this area must be much increased in practice, where we know these conditions are not fulfilled, but that a large surplus quantity of air is always admitted. A limit is thus found for the area over the bridge, or the area of the flue immediately behind the furnace, below which it must not be decreased, or the due quantity could not pass off, and consequently the due quantity of air could not enter, and the combustion would be proportionally imperfect. It will be found advantageous in practice to make the area two square inches instead of .516 square inch. The imperfection of the combustion in any furnace, when it is less than 1.5 square inch, will be rendered very apparent by the quantity of carbon which will rise unconsumed along with the hydrogen gas, and show itself in a dense black smoke on issuing from the chimney. This would give twenty-six square inches of area over the bridge to every square foot of grate, in a furnace in which the rate of combustion is thirteen pounds of coal on each square foot per hour, and so in proportion for any other rate. Taking this area as the proportion for the products of combustion immediately on their leaving the furnace, it may be gradually reduced as it approaches the chimney, on account of the reduction in the temperature, and consequently in the bulk of the gases. Care must, however, be taken that the flues are nowhere so contracted, nor so constructed, as to cause, by awkward bends, or in any other way, any obstruction to the draught, otherwise similar bad consequences will ensue.

An idea is very prevalent that it is advantageous to make the flame, or hot gases, (as they may be termed, because we may look upon flame merely as a stream of gases heated to incandescence,) impinge upon, or strike forcibly, the plates of a boiler at any bend or change of direction in the flue. The turn in the flue is therefore made with a square end, and with square corners; but it is difficult to see on what rational grounds the idea of advantage can be upheld. The gases, if they are already in contact with the plate, cannot be brought closer to it, and any such violent action is not necessary to alter the arrangement of the particles of the gases and bring the hotter particles to the outside, while there is a great risk of an eddy being formed, and of the gases being thrown back and returned upon themselves, when they strike the flat opposing surface; thus impeding the draught, and injuring the performance, of the boiler. That circulation will take place to a very great extent among the particles of

heated gases, flowing in a stream even in a straight flue, will be apparent from those particles next the surface being retarded by the friction against the sides, and by their tendency to sink into a lower position in the stream from their having been cooled down and become more dense. An easy curve is sufficient to cause great change in the arrangement of the particles, as those which are towards the outside of the bend have a much longer course to travel, and are thus retarded in comparison with the others. From these causes the hotter particles in the centre of the flowing mass are, in their turn, brought to the outer surface, and made to give out their heat. The worm of a still is never found returning upon itself with square turns, as if the vapor inside would be more rapidly cooled by its impinging on the opposite surface; yet the best form of worm is a subject which has engaged the attention of many able men, and therefore may well be taken by engineers as a guide in the management of a similar process, though carried on at a much higher temperature.

Another very prevalent practice, and which also would seem to be open to serious objections, is, that the flues are frequently made of much greater area in one part than in another. This arises from a desire to obtain a larger amount of heating surface than is consistent with the proper area of the flue, or with the amount of the heated gases which are passing through it. The flue is thus made shorter in its course than it ought to be in proportion to its sectional area. This is even sometimes done by placing a plate of iron partly across the flue, near the bottom of the chimney, thus suddenly contracting the passage for the gases. The effect of this is evidently to cause a very slow and languid current in the larger part of the flue, and the consequence is, that a deposition of soot rapidly takes place there. In many marine and land boilers, having one internal flue in them, of too large a size, this will be found to be the case, soot being soon deposited, till the flue is so filled up that the area left is only such as is due to the quantity of heated gases passing through it; the value of those parts of the sides of the flue which are covered with soot are thus lost. This is well exemplified in Mr. Dinnen's paper on marine boilers, in the Appendix to Weale's edition of Tredgold, where he states, that the flues of the boiler in H. M. Steamer "African," after she had performed a great deal of work, in the course of five weeks' time, during which period there was no opportunity of sweeping them, were found to be in exactly the same state as after a voyage of five days, or probably as they would have been found after a much shorter time, if they had been examined. These flues are about the same area throughout their whole length, but the chimney is of much less area. In the first portion of the flue from the fire no soot was deposited, but the deposit began after the first turn that the flue took, and gradually increased in amount to the foot of the chimney. The inference that may be drawn from this fact appears to be, that the gases, at first highly heated and thereby expanded, filled the first part of the flue, but as they were cooled they became more contracted in their bulk, regularly towards the chimney, and therefore allowed the soot to be deposited in the space not properly filled by

them in their course, and all soot subsequently formed was carried out at the chimney top by the velocity and power of the current. The amount collected near the foot of the chimney, and in the portions of the flue furthest from the fire, diminished the amount of the surface of the boiler exposed to the action of the heated gases, and the efficiency of the boiler was therefore impaired to the same extent. In those boilers in which the flues, before reaching the chimney, are very much too large, and are contracted, as has been stated, by a plate put across them, the extent to which their efficiency is thus impaired must evidently be much greater and to a serious extent, as this evil exists in them to a very much greater degree.

The due amount of heating surface that ought to be given in a flue to carry off the caloric, or to cool down a given quantity of heated gases, has not yet been investigated with any great degree of accuracy, and practice varies widely under different circumstances. The largest proportion is allowed in the Cornish boilers, some of which have not less than thirty feet and even forty feet of heating surface to one foot of grate. This appears to be more than is justified by any corresponding gain, and certainly more than would be advisable in any marine or locomotive boilers. In boilers burning thirteen pounds of coal per hour on each superficial foot of grate, a proportion of eighteen feet to each foot of grate will be found to give good results. Where slow combustion is carried on, and where an extra size of boiler is not objectionable, some advantage may be gained by increasing the amount in proportion to the amount of fuel consumed. In calculating this surface, it is usual not to include the bottoms of the square flues in marine boilers, and in circular flues from one-fourth to one-third of the surface should be deducted as bottom surface, and therefore not efficient as heating surface. It is not usual to make any distinction between horizontal and vertical surfaces, though it is probable that the former are considerably more valuable. The efficiency, however, of some boilers which have been made with vertical tubes, would rather tend to make it doubtful whether so much difference exists between the value of horizontal and vertical surfaces as has been generally supposed. If the area, instead of being in one large flue, be sub-divided into a number of small flues, or pipes, so as to expose the gases to the required amount of surface in a short course, the distance traversed between the fire-place and the chimney does not seem to be important. The velocity of the current of gases will not be materially influenced by their sub-division, as the whole amount of the surface with which the gases must come in contact, tending to impede their course by friction, will be the same in both cases. It is evident that numerous small flues, by sub-dividing the large stream of gases, which in the other case flow off in one body, bring the greater proportion of the particles at once into contact with the surfaces, and therefore render it unnecessary to pay the same amount of attention to the turning of the stream and the bringing out the hotter particles from the centre of the flowing mass. If these proportions of area through the flues and of heating surface be duly attended to, the results anticipated may be depended upon, whether

flues are of large area or are composed of a large number of small tubes.

The time occupied by the gases in passing through the boiler, from the instant of their generation to that of their leaving the boiler, and the length of the course through which they have traveled, have sometimes been looked upon as matters of great importance. Where the gases are traveling in one compact mass, it is evident that distance and consequently time (as the velocity with which the current flows is the same in all cases) must be allowed, for the different particles of this large mass so to circulate among themselves as that each may have an opportunity of coming into contact with a cooling medium, to give off its heat; but if the large mass of gases is so sub-divided that the different particles are sooner brought into contact with the due amount of cooling medium, then the time the gases remain in the boiler ceases to be of importance. When the gases have reached the foot of the chimney, in a well-proportioned boiler, they will be found to be reduced to a temperature of about 500° Fah, or below it; their bulk will, in consequence, be reduced by about one-third below their bulk on their first leaving the furnace. The reduction in the area of the flue ought not to be in the same proportion, because their velocity is no longer so great. The reduction ought to be made gradually, as has been stated before, and not by a sudden contraction at the foot of the chimney, as the effect of this is to cause a slowness of draught in the latter part of the flue, and consequently a deposition of soot; and then the surface so covered, which had been reckoned upon as effective heating surface, is lost. The area of a chimney, to allow the products of the combustion of each pound of coal consumed in an hour to pass off, should not be less than three-fourths of two square inches, this latter being the area given for the flue immediately behind the fire-place—that is, one and a half square inch; and for a boiler burning thirteen pounds of coal per hour, on each superficial foot of its grate, the area should be three-fourths of twenty-six square inches, or nineteen and a half square inches.

Theoretical research not having as yet given us any valuable assistance in determining the proper height of a chimney, we must again refer to practice as our guide. A good draught may be obtained with a very low chimney, but at a great expenditure of fuel, from the necessity that exists in such a case for allowing the gases to pass off at a much higher temperature than would otherwise be necessary. For a chimney built of brick-work the height ought not to be less than twenty yards, and may be increased to thirty yards or forty yards, with advantage to the economy of fuel. When chimneys are carried to a still greater height, it is generally for the purpose of carrying off the smoke, or any deleterious gases, from the immediate neighborhood, or to create a good draught with gases at a lower temperature than those from a steam-boiler furnace. On board steam vessels chimneys are limited in their height by the size of the ship, on account of the influence the chimney has on the stability and appearance. It will generally be found advantageous to make the chimney as high as these circumstances will permit. It will be found

to tend greatly to the efficiency of a boiler to allow a large space in it as a reservoir for steam. The surface for ebullition does not seem to be of much importance in comparison with this point.

In the application of the foregoing proportions to practice, no reference need be had to the form of the boiler; the same results will be obtained whether the boiler be circular, wagon-shaped, or any other form, if all the other circumstances be made the same. By due management in the process of firing, when these proportions are given to the furnace and flues, the combustion will be found to be such that but little carbon will pass off to be converted into smoke, and the results will show great economy in the consumption of fuel.

Civ. Eng. and Arc. Jour.

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*Remarkable Properties of Water and other Fluids, and their connexion with Steam-Boiler Explosions, being a Lecture read before the Members of the Royal Manchester Institution, February 17th*, 1845. *By* John Eddowes Bowman, Esq.

The lecturer commenced with a few preliminary remarks upon the relation which subsists between the *philosophy* and the *application* of science. It often happens, he observed, that theory follows in the wake of discovery, and that experience grows familiar with important details of practice, before the abstract principle involved, is sought out and clearly recognised. In what he advanced in the present lecture, however, a different sequence will be apparent, and we shall have an illustration of the value of a scientific application of common every day facts, in the solution of problems of the utmost moment to human life. He alluded to the property which liquids possess, of assuming the form of a globe or spheroid, when thrown upon any substance which is at a high temperature. Of this property, a familiar instance is afforded by an experiment performed every day in our laundries. When it is required to know whether a smoothing iron is sufficiently hot for her purpose, the laundress, on taking it from the stove, applies extemporaneously a drop of moisture from her mouth, and if this at once rolls off in the form of a globule, she knows by experience that the iron has reached a proper temperature: while if the drop of water bubbles and boils, however violently, the iron is condemned as not hot enough, and returned to the stove.

Once, then, in the flight of ages past it was discovered that water, though it so readily boils when thrown upon a moderately heated iron, does not boil at all when in contact with metal considerably more heated.

This fact, like many others equally familiar, has been allowed to lie unexplained and uninterrogated, during a long lapse of time; and it is only within the last few years that it has attracted any attention from the physical philosopher.

During his stay in Paris, he had an opportunity of seeing, in the laboratory of Dumas, some experiments performed by M. Boutigny, of Evreux, who has devoted a great deal of time to the subject, and

succeeded in bringing to light some most curious facts; so contrary, indeed, are some of his results to our preconceived ideas, that he confessed he should hardly have believed them possible, if he had not witnessed them. Some of these experiments he described, showing one or two of the most remarkable by way of illustration, and noticing the important consequences of this property of water, in being the frequent cause of steam-boiler explosions.

It is generally stated in books, that a red or white heat is necessary in order to throw the water into this globular form. Far lower temperatures, however, are sufficient. This may be proved by throwing some water into a saucer of melted lead, a metal which melts long before it becomes luminous in the dark: the water shows no appearance of boiling, but rolls about like a little crystal ball for a considerable time.

M. Boutigny, indeed, succeeded in forming a spheroid of water in a capsule floating on oil, heated to not more than 340°, which is about 600° below what is usually called "red heat."

Liquids more volatile than water become spheroidal at still lower temperatures. Alcohol, for instance, requires to be heated to 273°, ether not higher than about 140°; and it is found in general that those liquids which require the highest temperature for boiling, require also the highest to make them assume the spheroidal form.

Water and other liquids, when in the spheroidal state, slowly and gradually disappear, though no appearance of boiling is even observed. This is, of course, owing to slow evaporation, which goes on from every part of its surface, thus enveloping it with a film of vapor.

Of the extreme slowness of the evaporation, some opinion may be formed from the fact, which has been proved by direct experiment, that a quantity of water, which would, under ordinary circumstances, boil away at a temperature of 212° in *one minute*, will, if thrown into a vessel heated nearly to redness, require *little less than an hour* for its total dispersion.

[The lecturer here illustrated this property by dropping, from a glass tube, three or four drops of water into a red hot capsule of platinum, which he kept hot, and at the same time boiled about the same quantity in another capsule. The drops of water in the latter evaporated very rapidly, while those in the former became one spheriod, diminishing slowly in size, and rotating for a considerable time after the boiling water had entirely evaporated.]

We have seen, he continued, that when water is thrown upon a surface of red-hot platinum, it does not, as we might have expected, explode violently into steam; but, on the contrary, rolls calmly on its axis like a little world in space, and continues in the liquid state for a considerable space of time. Let us then endeavor to ascertain what is the temperature of the globule of water, and what relation it bears to that of the heated vessel, as well as to that of its own thin coating of vapor.

[Having again formed a spheriod in the same manner as before mentioned, he plunged into it the bulb of a delicate thermometer,

taking care that it did not come in contact with the heated metal. The temperature thus indicated was invariably 205°.]

Perhaps one of the most curious facts which have been established in connexion with this subject is, that any variation in the temperature of a vessel containing a spheroid, does not affect the temperature of the spheroid itself. Thus, it is found that a spheroid of water, when contained in a crucible heated considerably below redness, is just *as hot* as one contained in a crucible intensely heated to whiteness in the most powerful blast furnace!

From numerous experiments, indeed, with water, alcohol, ether, and many other liquids, the following law may be deduced:

*That bodies in the spheroidal state remain constant at a temperature below that of boiling, however high the temperature of the containing vessel may be.*

Pure alcohol, which, under ordinary circumstances, boils at a temperature of 173°, never rises, when in the spheroidal state, higher than about 170°; and ether, whose usual boiling point is about 100°, and which almost boils with the heat of the hand, *cannot be induced, when thrown into a crucible, heated to whiteness in a smith's forge, to rise above* 95°! The same remarkable results are obtained, if, instead of pouring the liquids while cold, into the red-hot vessels, they be absolutely *boiling* at the moment; strange and almost incredible as it may appear, the instant they reach their fiery resting place, they absolutely become cooler, and, as it were, shaking off the trammels of all known laws of nature, *cease to boil.* Liquids, then, when in that peculiar physical condition, which I have called *spheroidal*, always remain at one definite temperature; and this temperature is invariably, in the case of every liquid, lower than that at which, under ordinary circumstances, that liquid boils. Let us inquire a little more narrowly into the consequences of this law. Dr. Faraday, by a simple and ingenious contrivance, succeeded, some years ago, in condensing into the liquid state, several of the gases, which had, up to that time, resisted all such attempts, and had consequently been considered permanent gases, such as the air we breathe. This was the case with carbonic acid, chlorine, ammonia, sulphurous acid, and a few others. So great is the elastic force of these liquified gases, or, in other words, so prone are they to boil, and to pass again into the gaseous form, that a very great pressure is necessary to prevent their doing so, and unless the tube or other vessel containing them were very strong, it would probably be burst with a violent explosion. Now, it will readily be understood how it happens that these condensed liquids, unlike water and other fluids, do not require the application of artificial heat to make them boil, but, on the contrary, continue to boil, even when cooled far below the usual temperature of the air. Let us then inquire whether any of these liquids, whose boiling points are far below that at which water freezes, be subject to the same laws to which water is subject when they are thrown into a vessel sufficiently hot to cause them to pass into the speroidal state.

The gas which is the most easily liquified of those alluded to, is

sulphurous acid, which requires at a temperature of 45° a pressure equal to two atmospheres (or about 30 lbs. to the square inch of surface) to prevent its boiling. If this pressure be removed, violent ebullition takes place; and it has been found that, even when cooled as low as 14° of Fahrenheit's thermometer, or, in other words, 18° below the melting point of ice, it boils in precisely the same way as water boils when heated to 212°. Fourteen degrees, then, is the *boiling point* of sulphurous acid.

But we have found that when liquids, even while boiling, are thrown into a heated crucible they *become cooler*, and remain constantly at a temperature a few degrees below their boiling point. What, then, will be the effect of pouring into a red-hot crucible a few drops of liquid sulphurous acid? The experiment which was selected for the purpose of furnishing an answer to this question is, perhaps, one of the most striking and apparently paradoxical in the whole range of physical science. Liquid sulphurous acid is subject to the same remarkable law as water and other liquids, in being invariably, when in the spheroidal state, at a temperature lower than its boiling point, which is 14° of Fahrenheit, so that if a spheroid of sulphurous acid be formed, it remains constant at a temperature of about 12°, even though the crucible containing it be at a red or white heat. If a little water, contained in a small bulb, one-eighth or one-tenth of an inch in diameter, be immersed in the spheroid of acid, it is almost instantly frozen, thus affording incontestible evidence of the remarkably low temperature of the spheroid. Most persons have seen the well-known lecture-table experiment of causing water and other liquids to boil in vacuo at temperatures considerably below their ordinary boiling points, a result depending upon the diminished pressure on their surface.

When liquids in the spheroidal state, however, are placed under the receiver of the air-pump, and the air removed, no sign of boiling is even perceived. We may therefore suppose that the temperature of the spheroid in vacuo, is lower than when exposed to the atmospheric pressure, as otherwise ebullition would inevitably take place. The lecturer was not aware, however, that the temperature had ever been examined with a thermometer under these circumstances, and thought it would be by no means easily done.

He should, probably, scarcely be believed, when he stated that even liquid sulphurous acid does not, when contained in a red-hot crucible, and in the speroidal state, boil in vacuo.

If a thermometer is held in the atmosphere of vapor which surrounds a spheroid of water, it will give a far different result from that ensuing from its immersion in the globe itself.

Instead of indicating, as before, 205°, however hot the crucible may be, the degree at which it stands will now be found to depend entirely on the temperature of the latter. If it be heated to 400°, the thermometer will rise to that point; or if the crucible be raised to a red heat, a mercurial thermometer, graduated to 600°, is burst instantly, showing a temperature considerably higher. We have shown, experimentally, that when water is thrown into a red-hot crucible, it

does not, as common sense would have foretold, begin to boil, but remains constant at the temperature of 205°, so long as it retains the spheroidal form, however high the temperature of the crucible may be, but that the vapor surrounding it is, on the contrary, always about the same temperature as the crucible.

This comparatively low temperature of liquids in the spheroidal state, is generally attributed to the coating of vapor round the spheroid being incapable, as it is conceived, like all other gaseous bodies, of *conducting heat.* This explanation, however, though ingenious, does not meet all the difficulties of the case: for, besides the heat which would be conducted by the coating of vapor, if the vapor had the power of conducting it, (which is possible,) there is the enormous quantity of *radiant heat,* emanating from all parts of the heated crucible. If a vessel containing water be placed near a fire, it is well known that it gradually becomes warm, and if the fire be a good one, and the distance not too great, the water will shortly boil. The heat which causes the water to boil in this case, is not conducted by the fire to the water through the intervention of the air, since we know that air has no such power; but it is a portion of that which, like light from a candle, radiates from the fire in all directions, and is absorbed more or less completely by any substance which stands in its way, and intercepts its passage. Why, then, does not the spheroid of water, surrounded as it almost always is, by intensely heated metal, absorb the rays of heat, which dart towards it from every side, become intensely heated to the boiling point, and dispersed in vapor with explosive violence? In order to answer this question, some philosophers have stated that the radiant heat, when it meets with any liquid in the spheroidal state, passes through it without experiencing any interruption, and consequently does not impart any heat to it. A simple experiment is sufficient to show the fallacy of this hypothesis.

If a crucible be made red hot, and a small bulb of glass, containing water, be brought near to its inner surface, the water boils violently, owing to the absorption of radiant heat, and notwithstanding the presence of a quantity of non-conducting air between the heated metal and the water. This shows that heat *does* radiate from the sides of the crucible, and, too, in sufficient quantity to cause water to boil with considerable violence. If now the crucible be again heated to an equal degree, and a few drops of water poured in, they at once assume the spheroidal state. Things being in this condition, let the little glass bulb containing water be immersed in the spheriod, and it is found that the water does not show the slightest tendency to boil. The spheroid of water has consequently, in some way or other, prevented the rays of heat from reaching the glass bulb, and the water which it contained.

But if, according to this hypothesis, the radiant heat passed through the substance of the spheroid, without being to any extent absorbed or arrested by it, it would obviously reach the bulb containing the water, and cause it to boil with as much violence almost as it does when no spheroid is interposed between it and the source of heat.

Another mode of explaining the low temperature of liquids in the spheroidal state, is clearly pointed out by the result of this experiment, which proves, beyond all doubt, *that bodies in the spheroidal state have, when they have attained their maximum temperature, (which we have found to be always lower than their boiling point,) the remarkable property of reflecting, almost completely, radiant heat.*

A curious variation of the last experiment, tending to the same conclusion, may be made by putting a piece of ice into the red-hot crucible. It instantly absorbs sufficient heat to cause a portion of it to become spheriodal, after which it continues at a temperature of 205°, even though a portion of the ice remain unmelted within the globule. Thus the ice, and afterwards the water, which has an almost perfect *reflecting power* at 205°, absorbs, instantaneously, as it were, all the heat necessary to raise it to that temperature, and above which it does not become heated! *Why* and *how* is this? are questions which, in the present state of our knowledge, cannot be answered; and we have here one of those deep mysteries, so frequently met with in our researches into the hidden laws of nature, which baffle and confound the reason, and set at nought, for a time, at least, the power of the human mind.

We have seen that not only water, but also alcohol, ether, and liquid sulphurous acid, may be obtained in the peculiar condition, which he had, on account of the external form which always attends it, called the *spheroidal state.* It becomes interesting to inquire, whether so remarkable a change may be produced in other liquids. A great number of experiments have been made with almost every kind of liquid; solutions of acids, alkalies, and salts; compressed gases and melted solids; fats and oils of every kind, both volatile and fixed; and they tend to show that all liquids, with scarcely an exception, pass, under favorable circumstances, into the spheroidal state. The temperature necessary to produce this effect, appears to bear some relation to the boiling point; those which boil most readily requiring a lower temperature than the less volatile substances. That a drop of water, or other fluid, when in the spheroidal state, is poised, as it were, without support, at some sensible distance from the surface of the vessel containing it, may be proved in many ways. If a spheroid of some opaque substance be formed on a nearly flat surface, and then interposed between a lighted candle and the eye, the image of the flame is distinctly seen between the hot surface and the globule. This effect might be produced if the spheroid were in a state of rapid motion up and down, since the image of the candle, seen during the ascent, will remain visible till the next ascent; just as an ignited point in rapid revolution appears as a circle of light. That this is not the case, however, may be shown in another way. If silver be touched with nitric acid, it is rapidly corroded, and in a short time dissolved; but if a quantity of nitric acid be poured into a crucible or dish of silver, sufficiently hot to induce the spheroidal state, no corrosion whatever will take place—clearly proving that the acid is at no time in absolute *contact* with the metal. That this is not owing to any

deficiency in the strength of the acid, may be seen by placing in the spheroid a piece of *cold* silver, when violent action, of course, takes place, nitrous fumes being given off, and nitrate of silver formed. A remarkable effect may be produced, owing to this repulsion between liquids and heated solids, if a large spheroid of water be formed on a surface nearly flat, and a small bar of white or red hot iron be then thrust into the middle of it. *Contact* being impossible between the bar and the water, the latter forms a ring at some little distance from the heated bar, presenting very much the appearance of Saturn and his ring. Whether any real analogy exists between the two effects, or whether the causes be in any way connected, further researches into the nature of that anomalous appendage of the planet may perhaps decide.

We have now passed in review the most important phenomena presented by water and other liquids, when thrown into vessels raised to a high temperature. We found, in the first place, that water may be made to assume the globular form, when placed in a cup heated only to 340°, which is less than 130° higher than its boiling point; and that the temperature necessary to convert other liquids into spheroids bears some proportion to their several boiling points—that for alcohol being 273°, and that for ether, 140°. Secondly, we found that the rapidity with which water in the spheroidal state evaporates, is in proportion to the temperature of the heated vessel containing it, but that the evaporation of water in a spheroidal state is, at a temperature of 400°, fifty times more slow than that of ordinary boiling water at 212°. On examining into the temperature of liquids in the spheroidal state, we arrived at the remarkable result, that *whatever the temperature of the containing vessel may be, that of the spheroids is invariable, and always below their boiling points.* Thus, a spheroid of alcohol always stands at 170°, or 3° below its boiling point; one of ether is always 5° below, or 95°; and liquid sulphurous acid, which boils at 14°, never reaches even that low temperature when in the spheroidal state, but continues far colder than melting ice, even though the crucible in which it lies *be all the time at the most intense white heat.* Fifthly, we found that the only way of explaining this low temperature of spheroids, is to suppose that they have the property of reflecting, in a very perfect manner, the radiant heat emanating from the sides of the hot crucible, and are in this way protected from the scorching rays which would otherwise cause them to burst violently into steam. In the sixth place, it appeared that, with scarcely any exceptions, *all* liquids may be made to pass into the spheroidal state. And, lastly, there appeared strong evidence to prove that spheroids are never in absolute contact with the vessel containing them.

Prac. Mec. and Eng. Mag.

To be Continued.

## *Extract from a memoir upon the action of the Perchloride of Gold upon the Hyposulphite of Soda.**

It is known that, by mixing determinate quantities of perchloride of gold and hyposulphite of soda, previously dissolved in water, a liquid is prepared which is now used to fix daguerreotype pictures. The chemical nature of this liquid is completely unknown: we thought that a thorough examination of its composition and properties would furnish the means of remedying some of the inconveniences which it presents. The result has shewn that we were correct.

To obtain this liquid, the preparation and use of which are due to M. Fizeau, we dissolve one part, by weight, of chloride of gold in five hundred parts of pure water, and three parts of crystalized hyposulphite of soda in the same quantity of water. The solution of gold is then poured little by little into that of the soda, stirring the whole time: the liquid at first reddens, but soon becomes colorless. It is too dilute to be analyzed, and as it is impossible to concentrate it, we were compelled to have recourse to the mutual reaction of chloride of gold and hyposulphite of soda, dissolved in very small quantities of water. A liquid obtained under these circumstances, is very abundantly precipitated by alcohol, at 40°.

The reaction is the same as when we take the re-agents more dilute, only the mixture must be made with more precaution; especially, after each addition, we must wait until the discoloration is complete, otherwise we cannot avoid the formation of a brown substance, which is difficult to be got rid of, and which is the result of the reaction of the perchloride of gold upon the products first formed.

The precipitate obtained by alcohol from this solution is a mixture of several different salts; it is almost altogether composed of a salt which we are about to describe, but it contains, besides, variable quantities of all the products contained in the supernatant liquid.

To purify it, it is necessary to redissolve it several times in succession, in a small quantity of water, and to precipitate it each time by absolute alcohol.

The salt thus purified is perfectly colorless, crystalizes in needles, insoluble in strong alcohol, and but slightly in ordinary alcohol; but, on the contrary, excessively soluble in water. Its taste is sweet.

Its aqueous solution possesses all the properties of M. Fizeau's liquid; and, in fact, M. Lerebours, who has carefully compared the action of these two liquids, even gives a preference to the solution of our salt, in consequence of the richness of the tones which it gives to the picture.

It is the active material of M. Fizeau's liquid, freed from all foreign matters. Careful analyses shew its composition to be $S^2 O^2 AuO^2 + 3 (S^2 O^2 Na. O) + 4HO$.

* In a memoir by Messrs. Fordos & Gelis, published in a late number of the "Annales de Chimie," they describe a new salt, to which we desire to call attention, as likely to be of use to those engaged in daguerreotyping. Com. Pub.

It is, therefore, a double hyposulphite of gold and soda, with four equivalents of water.

The investigation of this salt, and of the supernatant liquid, shews that the action of the perchloride of gold upon the hyposulphite of soda, may be represented by the following equation:

$$8\,(S^2\,O^2\,Na.\,O) + Cl^3\,Au + 4\,(HO) = 2\,(S^4\,O^5\,Na.\,O) + S^3\,O^3\,Au.\,O, 3\,(S^2\,O^2\,Na.\,O)\,4\,HO.$$

There is therefore formed a bisulphuretted hyposulphate of soda, which plays no useful part in fixing the daguerreotype pictures; we may even say that, by the ease with which it abandons its sulphur under the influence of heat, it may contribute to the formation of those black spots which so often compel us to abandon the most perfect impressions. It is also probably owing to its presence that the change which M. Fizeau's liquid undergoes, when kept, is to be attributed. All those who have frequent occasions to use it, know that it can scarcely ever be kept for a month. This inconvenience renders it necessary for each amateur to prepare it for himself, which is difficult. For although the preparation is simple and easy for those who are accustomed to chemical experiments, it is by no means so for amateurs: to succeed, they must conform exactly to M. Fizeau's instructions, and especially employ perfectly pure materials, which it is not always easy to find in commerce.

We believe, therefore, that it will be found useful to substitute the salt which we have just described, in place of the liquid of M. Fizeau; it will then suffice, in order to obtain a suitable liquid, to dissolve one and a half parts, by weight, of the salt in one thousand of water. Such was the liquid used by M. Lerebours. In conclusion, this substitution will permit us hereafter to transport, in a very small bulk, quantities of this salt, which represent enormous masses of the liquid, and this last advantage will be particularly felt by traveling photographists. Ann. de Chim. et de Phys., April, 1845.

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*Experimental Researches into the Properties of the Iron Ores of Samakoff, in Turkey, and of the Hæmatite Ores of Cumberland, with a view to determine the best means for reducing them into the cast and malleable states; and on the relative strength and other properties of cast-iron from the Turkish and other Hæmatite Ores.* *By* William Fairbairn, M. Inst. C. E.

In the smelting and manufacturing of the poorer iron ores, as they are commonly called, being those in which a large proportion of alumina, silica, and other foreign matters are contained, many important improvements have in modern days been effected; but in the reduction of the richer sorts—hæmatite ores, those more nearly approaching pure iron, with very little admixture of other substances, there has been scarcely any change, from the old and expensive methods, which have for several centuries prevailed in this and other countries. It is remarkable that the proprietors of the richer minerals

should have allowed the makers of iron, from ores of leaner quality, such as the blackband and kidney ores, to have so far outstripped them.

Except the successful experiments of Mr. Heath, at the Works of Porto Nuovo, in the East Indies, and the attempts now making by the Cleator Company, near Whitehaven, there are few instances of improvements in the smeltings of rich ores, either in this country or on the continent. It has been stated, that the Swedish iron manufacturers have introduced some alterations into their works, but they appear to be of minor importance, and to be scarcely entitled to the name of improvements upon the old process used in that country for a long series of years.

It is to Mr. Ohanes Dadian, an active and enterprising Armenian, in the service of the Sublime Porte, that we are indebted for the present inquiry; and by that gentleman's determination to surmount every obstacle, and to solve the doubts of some eminent chemists, the present results were obtained. Amongst other duties devolving upon Mr. Dadian, in his recent visit to this country, was that of placing in the hands of competent persons, some samples of ores which were sent from Turkey, for the purpose of experiment. The first samples were small in quantity, but a more recent supply, accompanied with some specimens of bituminous coal, enabled the experimenters to enter upon the subject with increased confidence, and to pursue the inquiry with much greater prospects of success. In addition to this, Mr. Dadian had full power to engage persons duly qualified for the investigation, and whose skill and practical knowledge would entitle them to the support and confidence of their employers.

In consequence, Mr. W. N. Clay was engaged as chemist and metallurgist, and Mr. John Hague as engineer.

As the greater part of the experiments were conducted under the superintendence of these gentlemen, their separate reports are given in the order in which they were made; and to prevent confusion the facts are recorded as they occurred, from time to time, in the experiments.

Previous to Mr. Dadian's visit to England, he had collected information relative to the fuel, limestone, &c., in the district of country where the ore is found; and from the abundance and quality of the materials, it is presumed that a moderately cheap iron of very superior quality may be obtained.

From the description of the country, as given by Mr. Dadian and by Mr. Zohrab, who visited the locality some years since, it appears, that the ore is brought down the rivers from the higher districts, and is deposited in the lower valleys, at a short distance from the sea; extensive tracts of country are thus covered to a depth sufficient to insure an almost inexhaustible supply.

Before any definite plan could be adopted for the reduction of the ores, it was deemed necessary to ascertain, by careful analysis, their composition and value, and for these objects Mr. Dadian, when last in Paris, consulted Monsieur Dumas, the chemist, and from that gentleman he received a favorable report: that report is not in the author's

possession, but from statements received, it appeared only to have differed in a slight degree from that of Mr. H. H. Watson, of Bolton, whose analysis of the samples (which may be taken as a fair average of the whole) gave—

| | | | | |
|---|---|---|---|---|
| One atom | 28 | + one atom | 8 | = protoxide of iron. |
| Two atoms | 56 | + three atoms | 24 | = peroxide of iron. |
| | 84 | | 32 | |
| 84 metal | + | 32 oxygen | = | 116 black oxide. |

Then 116 : 84 : : 88 : 63.72 + quantity of metal per cent. in the ore in question by theory.

In this statement Mr. Watson observes, "that the oxide readily dissolves, when the ore is heated in powder with hydrochloride acid;" and by thus treating 100 grains of the ore, he obtained a solution of the oxide, and had 12 grains of siliceous earth undissolved; the proportions would therefore be—

| | |
|---|---|
| Protoxide of iron<br>Peroxide of iron | 88 |
| Siliceous earth | 12 |
| | 100 |

From the above it is evident that the ores are nearly pure oxides of iron; they are rich in quality, highly magnetic, and may be easily separated from extraneous matter by the magnet. In some of the processes this separation may or may not be necessary, but in case the silica be found injurious, the process of cleansing may be effected by a series of magnets fixed on the circumference of a wheel, which, in moving through the loose ore, would attract the iron and carry it round to a revolving brush, acting upon the periphery, and thus deposit the metal into a receiving box on the opposite side. This is probably the best method for obtaining the perfectly pure oxides; but the most expeditious mode would be to cleanse it with a fan, in the same way as farmers winnow grain, by blowing the lighter particles to a distance, and allowing the metallic granules, as being of higher specific gravity, to fall short into a separate receiver. A third method would be, to wash the ore in a current of running water, and thus free it from all superfluous matter not required in the process of manufacture. But in these different cleansing operations, an excess of the siliceous earths is assumed, and moreover that these mixtures are detrimental to the process of deoxidation, to be effected either before or after the change in the furnace.

Now, it is not altogether clear that such is the case, and in the absence of experiment it is reasonable to suppose, that instead of these earths proving injurious they might be found useful, in combining with the limestone as a flux, and thus vitrifying the silex at the same instant the deoxidating process is going on.

These opinions are entitled to some weight, as the separate reports of Mr. Clay and Mr. Hague (although their views are not altogether

similar) still inculcate the necessity of adopting some effective process of deoxidation.

Before adverting to the experiments, it will be necessary briefly to state the opinions of several manufacturers, to whom the ores were submitted for inspection, and to whose sound practical views the country is indebted for many valuable improvements in the chemical as well as the mechanical process of the art.

To the iron-maker and engineer, a minute chemical analysis is of less importance than a knowledge of the methods used in the treatment of similar ores, derived from experimental and practical research. It is true, that none of the iron ores of this country will bear a comparison, in point of richness, with those of Turkey, excepting, probably, the red ores of Lancashire and Cumberland, which, although varying in their chemical compounds, are in other respects comparative, and exhibit (with the exception of the magnetic properties) characteristics of a very similar description.

According to Dr. Colquhon, of Glasgow, the Ulverstone ore contains—

| | Grs. |
|---|---|
| Peroxide of iron, | 90.3 |
| Silica, | 5.0 |
| Alumina, | 3.0 |
| Lime, Magnesia, | traces. |
| Water, | 6.0 |
| | 104.3 |

This, by calculation, would give an average of 62 per cent. of iron, of nearly the same degree of richness as the ores of Samakoff, which, from Mr. Watson's analysis, yields 63.72.

Dr. Colquhon, in his inquiry into Mr. Clay's new process for making malleable iron direct from the ore, states, "that the red ores of Lancashire and Cumberland (which are a species of hæmatite) are exceedingly pure," and from an average sample, made up with great care, he found its constituents composed "of 63 per cent. of iron, 8 per cent. of earthy matter, and minute quantities only of lime and magnesia." In other respects the ores were entirely free from phosphorus, arsenic, and sulphur.

From this statement it is obvious that the Ulverstone ores, operated upon by Dr. Colquhon, do not widely differ from those analyzed by Mr. Watson; and viewing their other properties, they may be considered to approximate, irrespective of the quantity of metal produced in each.

Concerning the other iron ores of this country, unfortunately none of them are analogous to those of Turkey, either as regards their chemical constituents, or the process by which they are reduced. It is the opinon of all the practical iron masters who have been consulted, that in smelting, the latter would require a different treatment

from that pursued with the ores of this country; but in making malleable iron, they are all agreed as to its fitness for Mr. Clay's new process, and that large quantities of the finest quality might be made direct from the ore, at a moderate rate of charge.

On these points there is but one opinion, but the manufacturers are somewhat startled at the idea of a new process of preparation; the smelting being considered a work of difficulty, from the expense and trouble which must be incurred, before the preparatory process of roasting can be accomplished. In fact, these opinions would infer that the whole must be looked upon, for some time to come, as an experiment, and that more particularly as the material to be worked upon is entirely new, and may present features of an exceedingly obdurate and refractory character. To a certain extent these views may be correct, as an excess of silex might prove exceedingly troublesome, and even with every care in the process of smelting, instead of a carburet, (by which the melting pigs of this country are so well known, and so justly appreciated,) a silicate of iron might be the result. It is true, that a flux of lime and a certain proportion of aluminous clay might remove, or in a great degree neutralize, the effects: but that can only be determined by experiment, and with such obstacles in advance, it will be necessary to guard against them, and to arrange future operations with a view to their removal.

But supposing them to be overcome either by this, or by the cleansing process already alluded to, or by such other means as may be deemed expedient, it is then to be considered how the minute particles of the ore are to be retained in the furnace, during the application of a strong and intense blast. It is clear that some process of calcination must be adopted, in order, not only to deprive the ore of part of its oxygen in the first instance, but to effect its carburation, and to hold it together until it is fused. For these objects the following experiments were entered upon, under the directions of Mr. Clay and Mr. Hague.

The first operation was to convert one of the cupola furnaces (4 feet diameter) at the Canal Street Works, Manchester, into a blast furnace; this was effected by lining it with fire-bricks to a height of 15 feet, leaving a hearth of 18 inches square, and 18 inches deep; it was made 2 feet 6 inches diameter at the boshes, and tapered to 18 inches at the top; with this furnace, and a moderately good fan blast, the experiments were made.

Previous to making the experiments at Manchester, Mr. Hague had tried the ores in various ways, and had subjected them to analysis and experiment. The first was made with only

| | |
|---|---|
| 4 | oz. of iron ore, |
| 4 | oz. of chalk, |
| 3 | oz. of bottle glass, |
| ¾ | oz. of charcoal, |
| ½ | oz. of clay. |
| 12¼ | oz. |

which, having been deoxidized in a close vessel, and melted in the

crucible, produced a super-carburet of good No. 1 pig iron, and which worked freely under the chisel and file.

The next experiment was on a larger scale, and consisted of

30 lbs. of iron ore,
10 lbs. of bottle glass,
8 lbs. of clay.

48 lbs.

This, after being roasted, was pulverized, and mixed with water; it was then formed into bricks, and subsequently melted, with a limestone flux, in the cupola, by a fan blast, and produced a hard white iron, of a quality varying between No. 3 and No. 4 pigs.

The last experiment was repeated, with the addition of 2 lbs. of clay and 2 lbs. of common salt; 10 lbs. of scoria from the last melting being substituted for the bottle glass. The produce of this mixture was a white No. 3 iron, nearly the same as the last.

Other tests of a similar kind were made, with nearly the same success, but no change of any moment occurred in the quality of the iron, until experiments on a more extended scale were adopted. These are given in the words of the experimenter.

To be Continued.

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*An Account of the cause of the Colors in Precious Opal.* *By* Sir David Brewster.

This gem is intersected in all directions with colorific planes, exhibiting the most brilliant colors of all kinds. The cause of these colors has never, we believe, been carefully studied. Mineralogists, indeed, have said that they are the colors of thin plates of air occupying fissures or cracks in the stone; but this is a mere assumption, disproved by the fact that no such fissures have ever been found during the processes of cutting out, grinding, and polishing, which the opal undergoes in the hands of the lapidary. In submitting to a powerful microscope specimens of precious opal, and comparing the phenomena with those of hydrophanous opal, Sir David Brewster found that the colorific planes or patches consist of minute pores or vacuities arranged in parallel lines, and that various such planes are placed close to each other, so as to occupy a space with three dimensions. These pores sometimes exhibit a crystalline arrangement, like the lines in sapphire, calcareous spar, and other bodies, and have doubtless been produced during the conversion of the quartz into opal by heat under the peculiar circumstances of its formation. In some specimens of common opal the striature is such as would be produced by a kneading of crystallized quartz when in a state of paste. The different colors produced by these pores arise from their different magnitude or thickness, and the colors are generally arranged in parallel bands, and vary with the varying obliquities at which they are seen.

Athenæum.

### *Experiments with Iron Targets at the Arsenal, Woolwich.*

The following experiments were undertaken lately, to determine the effect of shot upon the hull of an iron vessel, and also with the view of providing means for stopping the passage of water through a shot-hole near the water line. This latter object is sought to be effected by packings of various kinds fixed behind the sheathing-plates, which by their elasticity will close over the hole after the passage of the shot through them.

The gun used in these experiments is a 32 pounder, placed at the distance of 30 yards from the target, and was loaded with the full charge of 10 lbs. of powder, and also with 2 lbs. and 1 lb. to produce the effect of a spent shot.

The initial velocity of the ball with the full charge is about 1800 feet per second, and with a 2 lbs. charge, 1000 ft. The diameter of the shot is 6 inches.

*Target No.* 1 is made of three thicknesses of ½ inch plates rivetted together by double rows of rivets arranged in rectangles of 24 inches × 14 inches. A shot fired through this with the full charge made a clean hole of its own diameter, with very little tearing or raising of the edges, and no rivet head started near the hole. The round piece cut out by the shot is broken into angular splinters of one, two, or three inches long, which diverge from the hole in all directions and with great violence. When the full charge is used no disturbance in the plate or the rivets round the hole is observable.

This target was not stiffened with angle-irons.

No lining is placed behind this target.

*Target No.* 2 is formed of single ½ inch plates, flush jointed, single-rivetted, with frames 9 inches deep attached by double angle iron 6 × 3 inches. The frames are 33 inches apart.

One half of this target is lined at the back with pure India-rubber, and the other half with a mixture of India-rubber and cork-dust, containing 25 per cent. of the latter by weight; it is 12 inches thick. These linings are held to the sheathing by 1 inch screw-bolts with square heads outside, and nuts with washers of $\frac{5}{16}$ inch plate, 8 inches square inside, the washers completely covering the elastic lining. The bolts are in the centre of each square, or 8 inches apart.

Through the India-rubber and cork-dust, five shots were fired, all striking as was intended between the heads of the bolts. Two shots with the 10 lb. charge made clean perforations through the outer plate and passed through the lining without shattering it much, but each shot knocking off four or five of the back plates with great violence. The splinters from the outside plate all passed through the lining and radiated as before mentioned. After the passage of the shot, the elastic lining closed completely over the hole, so as to become impervious to light and apparently to water.

Several proportions of India-rubber to cork-dust have been tried, but the proportion before mentioned is considered the best. Three other shots were fired through this lining with the 2 lb. charge of powder, and were purposely made to strike within a circle of 12

inches diameter, so that the three holes joined; still the lining closed over the holes so as to exclude light, or prevent the passage of a thin walking-stick through it in any direction, which was considered very satisfactory. Of course, a great many of the back plates, about eight, were torn off.

With the small charge of powder the sheathing-plate suffers much more than with the full charge, the plate being considerably drawn into the hole, raising the edge inside, and stripping off the rivet heads near it. A shot fired with one pound of powder produced this effect in a greater degree, but in all cases the ball seems to carry with it a part of the outside plate torn from the hole, the piece increasing in size with the velocity of the cannon ball.

During an experiment with this target on the 3d June, a splinter struck a sentinel on duty at about 200 yards distance, passing entirely through the calf of his leg. It was a flat piece about the size of a penny, and must have glanced from the target at a very obtuse angle, and returned by the resistance of the atmosphere to where the man was standing, which was some way in advance of the horizontal line of the target.

A weak shot was passed through the lining of solid India-rubber, (12 inches thick,) which completely closed over the hole, apparently excluding the passage of water, and even air. This shot caused a great dislocation of the plates at the back, a number of which were driven off by the breaking of the nuts, consequent on the pressure thrown upon them by the tenacity of the India-rubber. The targets are 6 feet square.

*Target No.* 3 is formed of double $\frac{1}{2}$ inch plates rivetted together, and no frames. Half of this target is lined with solid India-rubber 8 inches thick, and held on by screw bolts and square washers as before. One chief objection to India-rubber as a lining for ships is its great expense. It would be also difficult to *confine* it in warm climates, as it assumes a kind of semi fluid motion when acted on by its own gravitation. The other half of this target is lined with a mixture of India-rubber and cork-dust, 12 inches thick, held on as before. In this case the cork-dust (which is cork chopped very fine) was in too large a proportion for the India-rubber, and consequently the hole formed by the shot did not close, and the lining itself was very much shattered.

*Target No.* 5 is formed of two plates, having a space of 10 inches between them, half of this space being filled in with felt, and half with India-rubber and cork-dust introduced in small pieces through hand-holes cut in the ceiling-plate between the frames, (which are 15 inches apart.) The outer sheathing-plate is $\frac{3}{8}$ inch thick, and the inner $\frac{5}{16}$ inch. The felt proved of no use in stopping the hole, and by its pressure it tore away a large portion of the ceiling-plate, about two square feet, where the ball passed through. This large piece was quite detached from the plate in various fragments which seem to have broken off quite short. A similar effect was produced in the ceiling-plate by the passage of the ball through the lining of India-rubber and cork-dust, and the latter from being introduced in small

pieces by the hand-holes did not close over the hole, and was very much shattered.

Effect of a 10 lb. charge.

Effect of a 2 lb. charge.

Effect of a 1 lb. charge.

It is found that a ball, whatever be its velocity, produces much the same effect upon the elastic lining, although not so with the iron plate, as we have shown. This will be better illustrated by the annexed sketches of the effect produced on the plate by different charges of gunpowder. Glas. Mec. Jour.

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### *Mode of Neutralizing the Local Attraction of Iron Ships on the Compass.*

Mr. C. D. Hays, who conducted two experimental voyages between London and Cork, with the view of testing his patent method of applying the joint powers of the steam-engine and the screw as auxiliaries to sailing vessels, has made, at the same time, some observations on the effects of iron vessels on the compass, which promise to be of great service. In a pamphlet on the subject he states:—"With a view of obtaining more correctly the error of the compasses, a person was taken on board to go as far as Gravesend, to endeavor to regulate them by the different bearings; but from the great variety found in every alteration of position of the ship's head, he could come to no satisfactory conclusion; he was then kept on board to proceed further down channel. Shortly after leaving Gravesend, Mr. Hays placed a triangle immediately over the rudder-head, on which he placed an azimuth compass, which, when compared with the direction of the river, appeared to indicate the position of the ship's head correctly, and from observations subsequently made, was found to act with the most perfect exactitude.

"Observations were continued from different bearings of the lights and headlands compared with the courses and distances made during the whole of the voyage to and from Cork, as well as from corrections while in port, from the whole of which, the compass over the rudder-head was found *exactly correct*, while that in the binnacle varied from one to three points. Compasses were also placed in different parts of the vessel, but in every other position than *immediately* over the stern-post and rudder-head, a variation was shown. The common compass, as well as the azimuth, was placed over the rudder-head, and showed the same results.

"The height of the triangle on which the compass was placed from the head of the rudder was three feet six inches, the axis of the needle exactly plumbing the top of the iron post of the rudder; raising and lowering it produced no alteration.

"The idea of placing the compass in that position suggested itself to Mr. Hays from a conversation he had with Captain Hoskin, of the *Great Britain* screw iron steam-ship, on the subject of the trouble and difficulties attending the direct regulation of the compass on board iron vessels, in which Captain Hoskin mentioned that, when they were correcting the compasses on board that ship at Bristol, it appeared to him the error diminished the nearer the compass was placed over the rudder-head and stern-post.

"Inferring from the above fact, that the neutralization was effected by the perpendicular attraction of the upright bars of the iron forming the mainpiece of the rudder on the needle, Mr. Hays placed a bar of iron immediately under the compass in the binnacle, as well as under compasses placed in other parts of the vessel, but without producing any sensible effect; that, however, he does not think sufficient to upset the theory of the perpendicular attraction, as the bars so placed were not a fourth-part of the length of the stern-post or mainpiece of rudder; and in giving the results of the above observations he merely wishes to publish a fact which may prove valuable in adjusting the compasses on board iron vessels. The method now employed consists in counteracting the local attraction of the vessel by the more powerful attraction of magnets placed about the compass, which not only are subject to variation of power by lapse of time and other causes, but may be displaced, destroyed, or lost, from numberless accidents to which vessels are subject at sea." Athenæum.

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## *Metals and Metallic Properties.*

On Saturday last, Professor Faraday continued his series of lectures on metals and metallic properties, by discussing the peculiar characteristics of iron, and, in connexion with it, those of steel. The extreme malleability of the former was clearly demonstrated, and illustrated by various beautiful experiments; its tenacity and ductibility being also ably dilated on, as well as its affinity for the other metals. Some fine specimens of the ore were displayed, and the inherent properties of the metal in that undeveloped state ably considered. The lecturer described the process of rendering the metal at once tough and strong, being thus adapted for purposes requiring such valuable features; and stated that this property of toughness was easily removed by a violent concussion, and mentioned the fact of Mr. Nasmyth's opinion being, that the axles of railway carriages so frequently snapped asunder, though previously rendered of extreme toughness and strength, from the constant percussion occasioned by the wear and tear of 3000, or upwards, of miles of traveling. The original qualities were, however, easily reinstated by a repetition of the same process that first gave it the necessary adjuncts. The properties of steel, and its formation from the parent mineral, iron, were practically illustrated. The iron being submitted to a high heat, the carbon crept into the metal, as in the manufacture of iron it crept out, and the result was, the formation of a new and exceedingly valuable metal, possessing all the toughness and malleability of iron,

and the fusibility of cast-iron, while, at the same time, its increased hardness rendered it capable of receiving the finest edge and the highest polish. Some very beautiful specimens of swords, both of home and foreign manufacture, were exhibited by the lecturer: that presented by the Emperor of Russia to Sir Edward Codrington, for his victory at Navarino, being of Siberian manufacture, and bearing on it representations of that battle, and inclosed in a beautiful sheath, overlaid with velvet and inwrought with gold, attracted very universal interest. The mode of testing the sufficient capabilities of steel, when fabricated into swords, was shown in a very complete manner: the sword was screwed tightly by the hilt to a lever, and suddenly, with an immense spring, let descend on a block of hard timber, this trial being repeated on its back, front, side, and edge; if withstanding these shocks, it was considered sufficiently strong, and accepted from the manufacturer at a high price, for the use of our military and naval establishments, while those that broke in their submission to this process were rejected. In conclusion, the lecturer briefly alluded to the properties exclusively belonging to iron, as exhibited by the loadstone in the phenomenon of electricity: illustrations were given of its amazing powers, and its adaptation to our wants cursorily alluded to. Mining Jour.

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### *Zinc Thread.*

The *Moniteur Industriel* announces that an important discovery in the manufacture of zinc thread has been effected by M. Boucher, who, after many essays, has at length been able to produce zinc threads of any diameter, of great suppleness, and presenting all the qualities of an excellent metal thread. In all cases where great tension is not required, this thread can be substituted with advantage for that of iron, brass, or copper. The price of zinc has doubled during the last few years, but, notwithstanding, M. Boucher vends his thread at a lower price than the galvanic iron thread, and considerably less than brass thread. Mec. Mag.

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### *On the Corrosion of Metals. By* Mr. Adie.

The object was to give an experimental proof of the fact, of water, when saturated with common salt, preserving, to a great extent, the surfaces of oxidizable metals from corrosion, by the joint action of air and water; and, also, to show that water, or water containing a saline solution, does not act as a corroding agent without the aid of the oxygen of the atmosphere. These positions were demonstrated by the details of several series of experiments which were purely of a chemical tendency, leaving to the engineers the application to practice of the results obtained. The details were also given of some experiments made to ascertain the quantity of oxygen dissolved by water under different circumstances; whence it was shown that brine, and some other saline solutions, contain much less dissolved oxygen than

sea or ordinary water; the discovery of this fact suggested the experiments on the application of brine as a preserver of iron. The object of the last set of experiments was to determine, by trial, the rates of corrosion of metals in fresh water, sea water, and saturated brine. The results demonstrated that sea water corrodes the quickest, fresh water less rapidly, and brine very much slower than either. The circumstance was incidentally mentioned of the use of common salt for preserving ships' timbers, for which purposes the spaces between the ribs of some of the North American ships are frequently packed with rock salt, and the effect has proved advantageous to the duration of the timber, without affecting the metal fastenings, as would have been supposed.—*Proceed. Inst. Civ. Eng.*

Athenæum.

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*On the Air Engine. By* Mr. J. Stirling.

The paper read was by Mr. J. Stirling, and described an Air Engine, invented by his brother and himself. The movements are founded on the well-known pneumatic principle, that air has its bulk or pressure increased or diminished in proportion as its temperature is raised or lowered. The application of this principle was exemplified by drawings, and a model exhibiting a machine composed of two strong tight air vessels, connected with the opposite ends of a vertical cylinder, in which a piston works in the usual manner. Within these air vessels are suspended two air-tight vessels, or plungers, filled with non-conducting substances, and attached to the opposite extremities of a beam, capable of moving up and down alternately, to the extent of one-fifth of the depth of the air-vessels. By this motion of the plunger, the air which is in a heated state below is moved to the upper part of the vessel, and in its transit traverses a series of vertical capillary passages between three metalic plates, which absorb the major part of the caloric. The remainder is taken up by a refrigerator of tubes filled with water. The air at the heated end is about 700 degrees, and has a proportionate pressure; when it arrives at the cooled end it is reduced to about 150 degrees, and the pressure diminished to a corresponding extent. Therefore, as the internal vessels move in opposite directions, it necessarily follows that the pressure of the condensed air in one vessel is increased, while that of the other is diminished. A difference of pressure is thus produced upon the opposite ends of the piston, and a reciprocating motion results, which communicates through a beam, connecting rod, crank, and fly-wheel to the machinery when driven. Machines on this principle were stated to have been worked, for some years past, at Dundee, with considerable saving of fuel, as compared to a steam-engine of similar power, and doing the same work. It is now proposed to adapt it to marine purposes, to which, from its simplicity and slight expenditure of fuel, it appeared well fitted. Ibid.

### *On Benzoline. By* Dr. Fownes.

Pure oil of bitter almonds is converted, by the action of a strong solution of ammonia, into a solid white substance, having a crystalline form, and which was termed by M. Laurent *hydrobenzamide*. The author found that this substance, by the further action of alkalies, became harder and less fusible than before, and not differing in chemical composition from the original substance, but exhibiting the properties of an organic salt-base. To this substance the author gives the name of Benzoline. He finds that the salts which it forms by combinations with acids are, in general, remarkable for their sparing solubility, and that many of them, as the hydrochlorate, the nitrate, and the sulphate, are crystallizable; of the properties of these salts the author gives a detailed account.—*Proceed. Royal Society.*

Ibid.

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### *On the Solubility of Oxide of Lead in Pure Water. By* Lieut. Col. Philip Yorke.

It is from this property that leaden pipes and cisterns become dangerous, when the water which fills them is soft and pure. The lead, however, which the water takes up may be removed by filtering the water through paper; a circumstance which has been explained by supposing that the oxide of lead is not really dissolved in the water, but merely suspended in it. The author, however, shows that the oxide of lead is taken up by the substance of the paper and combines with it, from an affinity such as subsists between the same metallic oxide and cotton fibre; the last taking the oxide from solution in lime-water, and lead being often fixed as a mordant on cloth for dyeing in this way, according to the statement of Mr. Crum. He finds also that the power of the filter may be exhausted, and that therefore it would be unsafe to trust to the action of a filter to separate oxide of lead from water for an unlimited time.—*Proc. Chem. Soc.*

Ibid.

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### *Experiments on Ozone. By* Mr. Williamson.

The name ozone was given by Schönbein to the substance which occasions the peculiar smell possessed by oxygen gas when produced by the voltaic decomposition of water, and he has made it the subject of much ingenious speculation, concluding that it is a new elementary body, and that it is derived from the decomposition of nitrogen, supposed to be of a compound nature. The last of these opinions, however, has already been disproved by Marignac, who demonstrated that the ozone odor was produced by the decomposition of water free from nitrogen. Mr. Williamson's experiments go to prove that ozone is a compound body, and that one of its elements is hydrogen; for having excluded the last element from any other source, by obtaining the oxygen gas with ozone from the decomposition of a salt of copper, a process in which no hydrogen is generated, and passing the oxygen over metallic copper which had been reduced by carbonic

oxide gas, a sensible formation of water always resulted. The bleaching power of ozone shows it to be a peroxide; and it must therefore be a higher oxide of hydrogen than water, although not the peroxide of hydrogen of Thenard, which is not volatile like ozone, but inodorous and fixed. Mr. Williamson finds also that the substance produced by the action of phosphorus on air is different from ozone, and that its effect, observed by Schönbein in decomposing iodide of potassium and liberating iodine, is the result of the joint action of phosphoric acid and free oxygen upon a solution of that salt. Ibid.

### *Time and the Electric Telegraph.*

We have heard of things being done "in less than no time," and always looked on the phrase as a figure of speech signifying great dispatch. This parodox seems, however, to have been actually realized in the case of Wheatstone's Great Western Telegraph, a message having been sent in the year 1845, and received in the year 1844! It appears that directly after the clock had struck 12, on the night of the 31st of December last, the superintendent at Paddington, signalled his brother at Slough that he wished him a happy new year: an answer was immediately returned, suggesting that the wish was premature, as the new year had not yet arrived at Slough! Such indeed was the fact, for "panting" Time was matched against Professor Wheatstone, and beaten half a minute. Reading Mercury.

### *A New Glass.*

Styrole is a volatile oil, obtained by distilling the balsam styrax or storax, although only in small quantity, and has a general analogy to benzoin. In one property styrole is, perhaps, the most extraordinary of substances; a limpid fluid at ordinary temperatures, it becomes a transparent colorless glass when heated up to a certain point, and remains so when it again becomes cool—a circumstance which will draw the attention of optical inquirers to styrole. In distilling storax to obtain this liquid, 20 parts of storax are mixed with 7 parts of carbonate of soda, and water put into the retort. In one experiment, 41 pounds of balsam yielded 12 ounces of styrole; in another, 27 pounds yielded 3 ounces. The fresher and softer the storax, the more productive is it of styrole. Lond. Mech. Mag.

## *Extracts from the Transactions of the Fifteenth Meeting of the British Association for the Promotion of Science.*

### *Extracts from the President's Address.*

Lord Rosse's Telescope.—The last year must ever be considered an epoch in Astronomy, from its having witnessed the successful completion of the Earl of Rosse's six feet reflector—an achievement of such magnitude, both in itself as a means of discovery, and in respect of the difficulties to be surmounted in its construction, (difficulties which perhaps few persons here present are better able from experience to appreciate than myself,) that I want words to express my

admiration of it. I have not myself been so fortunate as to have witnessed its performance, but from what its noble constructor has himself informed me of its effects on one particular nebula, with whose appearance in powerful telescopes I am familiar, I am prepared for any statement which may be made of its optical capacity. What may be the effect of so enormous a power in adding to our knowledge of our own immediate neighbors in the universe, it is of course impossible to conjecture; but for my own part I cannot help contemplating, as one of the grand fields open for discovery with such an instrument, those marvellous and mysterious bodies, or systems of bodies, the Nebulæ. By far the major part, probably, at least, nine-tenths of the nebulous contents of the heavens consist of nebulæ of spherical or elliptical forms, presenting every variety of elongation and central condensation. Of these a great number have been resolved into distinct stars, and a vast multitude more have been found to present that mottled appearance which renders it almost a matter of certainty that an increase of optical power would show them to be similarly composed. A not unnatural or unfair induction would therefore seem to be, that those which resist such resolution do so only in consequence of the smallness and closeness of the stars of which they consist; that, in short, they are only optically and not physically nebulous. There is, however, one circumstance which deserves especial remark, and which, now that my own observation has extended to the nebulæ of both hemispheres, I feel able to announce with confidence as a general law, viz: that the character of easy resolvability into separate and distinct stars, is almost entirely confined to nebulæ deviating but little from the spherical from; while, on the other hand, very elliptic nebulæ, even large and bright ones, offer much greater difficulty in this respect. The cause of this difference must, of course, be conjectural, but, I believe, it is not possible for any one to review *seriatim* the nebulous contents of the heavens without being satisfied of its reality as a physical character. Possibly the limits of the conditions of dynamical stability in a spherical cluster may be compatible with less numerous and comparatively larger individual constituents than in an elliptic one. Be that as it may, though there is no doubt a great number of elliptic nebulæ in which stars have *not* yet been noticed, yet there are so many in which they *have*, and the gradation is so insensible from the most perfectly spherical to the most elongated elliptic form, that the force of the general induction is hardly weakened by this peculiarity; and for my own part I should have little hesitation in admitting all nebulæ of this class to be, in fact, congeries of stars. And this seems to have been my father's opinion of their constitution, with the exception of certain very peculiar looking objects, respecting whose nature all opinion must for the present be suspended. Now, among all the wonders which the heavens present for our contemplation, there is none more astonishing than such close compacted families or communites of stars, forming systems either insulated from all others, or in binary connexion, as double clusters whose confines intermix, and consisting of individual stars nearly equal in apparent magnitude, and crowded

together in such multitudes as to defy all attempts to count or even to estimate their numbers. What *are* these mysterious families? Under what dynamical conditions do they subsist? Is it conceivable that they can exist at all, and endure under the Newtonian law of gravitation without perpetual collisions? And, if so, what a problem of unimaginable complexity is presented by such a system if we should attempt to dive into its perturbations and its conditions of stability by the feeble aid of our analysis. The existence of a luminous matter, not congregated into massive bodies in the nature of stars, but disseminated through vast regions of space in a vaporous or cloud-like state, undergoing, or awaiting, the slow process of aggregation into masses by the power of gravitation, was originally suggested to the late Sir W. Herschel in his reviews of the nebulæ, by those extraordinary objects which his researches disclosed, which exhibit no regularity of outline, no systematic gradation of brightness, but of which the wisps and curls of a cirrhus cloud afford a not inapt description. The wildest imagination can conceive nothing more capricious than their forms, which in many instances seem totally devoid of plan, as much so as real clouds,—in others offer traces of a regularity hardly less uncouth and characteristic, and which in some cases seem to indicate a cellular, in others a sheeted structure, complicated in folds, as if agitated by internal winds.

Should the powers of an instrument such as Lord Rosse's succeed in resolving these also into stars, and, moreover, in demonstrating the starry nature of the regular elliptic nebulæ, which have hitherto resisted such decomposition, the idea of a *nebulous matter*, in the nature of a shining fluid, or condensible gas, must, of course, cease to rest on any support derived from actual observation in the sidereal heavens, whatever countenance it may still receive in the minds of cosmogonists from the tails and atmospheres of comets, and the zodiacal light in our own system. But though all idea of its being ever given to mortal eye to view aught that can be regarded as an outstanding portion of primæval chaos be dissipated, it will by no means have been even then demonstrated that among those stars, so confusedly scattered, no aggregating powers are in action, tending to draw them into groups and insulate them from neighboring groups; and, speaking from my own impressions, I should say that, in the structure of the Magellanic clouds, it is really difficult not to believe we see distinct evidences of the exercise of such a power. This part of my father's general views of the construction of the heavens, therefore, being entirely distinct from what has of late been called "the nebulous hypothesis," will still subsist as a matter of rational and philosophical speculation,—and perhaps all the better for being separated from the other.

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Nebulous Hypothesis.—Much has been said of late of the Nebulous Hypothesis, as a mode of representing the origin of our own planetary system. An idea of Laplace, of which it is impossible to deny the ingenuity, of the successive abandonment of planetary rings, collecting themselves into planets by a revolving mass gradually

shrinking in dimension by the loss of heat, and finally concentrating itself into a sun, has been insisted on with some pertinacity, and supposed to receive almost demonstrative support from considerations to which I shall presently refer. I am by no means disposed to quarrel with the nebulous hypothesis even in this form, as a matter of pure speculation, and without any reference to final causes; but if it is to be regarded as a demonstrative truth, or as receiving the smallest support from any observed numerical relations which actually hold good among the elements of the planetary orbits, I beg leave to demur. Assuredly, it receives no support from observation of the effects of sidereal aggregation, as exemplified in the formation of globular and elliptic clusters, supposing *them* to have resulted from such aggregation. For were this the cause, working itself out in thousands of instances, it would have resulted, *not* in the formation of a single large central body, surrounded by a few much smaller attendants, disposed in one plane around it,—but in systems of infinitely greater complexity, consisting of multitudes of nearly equal luminaries, grouped together in a solid elliptic or globular form. So far, then, as any conclusion from our observation of nebulæ can go, the result of agglomerative tendencies *may*, indeed, be the formation of families of stars of a general and very striking character; but we see nothing to lead us to presume its further result to be the surrounding of those stars with planetary attendants. If, therefore, we go on to push its application to that extent, we clearly theorize in advance of all inductive observation.

But if we go still farther, as has been done in a philosophical work of much mathematical pretension, which has lately come into a good deal of notice in this country,* and attempt "to give a mathematical consistency" to such a cosmogony by the "*indispensable criterion*" of "a numerical verification,"—and so exhibit, as "necessary consequences of such a mode of formation," a series of numbers which observation has established independent of any such hypothesis, as primordial elements of our system—if, in pursuit of this idea, we find the author first computing the time of rotation the sun must have had about its axis, so that a planet situate on its surface and forming a part of it should not press on that surface, and should therefore be in a state of indifference as to its adhesion or detachment—if we find him, in this computation, throwing overboard as troublesome all those essential considerations of the law of cooling, the change of spheroidical form, the internal distribution of density, the probable non-circulation of the internal and external shells in the same periodic time, on which alone it is possible to execute such a calculation correctly; and avowedly, as a short cut to a result, using as the basis of his calculation "the elementary Huyghenian theorems for the evaluation of centripetal forces in combination with the law of gravitation;" —a combination which, I need not explain to those who have read the first book of Newton, leads direct to Kepler's law;—and if we find him then gravely turning round upon us, and adducing the co-

* M. Comte, Phil. Positive, ii. 376.

incidence of the resulting periods compared with the distances of the planets with this law of Kepler, as *being* the numerical verification in question,—where, I would ask, is there a student to be found who has graduated as a Senior Optime in this University, who will not at once lay his finger on the fallacy of such an argument,* and declare it a vicious circle? I really should consider some apology needed for even mentioning an argument of the kind to such a meeting, were it not that this very reasoning, so ostentatiously put forward, and so utterly baseless, has been eagerly received among us† as the revelation of a profound analysis. When such is the case, it is surely time to throw in a word of warning, and to reiterate our recommendation of an early initiation into mathematics, and the cherishing a mathematical habit of thought, as the safeguard of all philosophy.

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## *Extracts from the Proceedings.*

Dent's Ship Compass.—Mr. Dent then addressed the section on his proposed method of supending a ship's Compass. An account of this instrument was communicated to the Association at its last meeting in York. Mr. Dent now read extracts from a report of the working of this compass during six months at sea, as ordered by the Lords of the Admiralty, the amount of which was, that his compass was found "to be extremely sensitive, moving exactly and admirably with the ship's head, when the helm was put hard-a-port and hard-a-starboard: while the other compasses with which it was compared were always in arrear."

Dr. Lloyd asked whether Mr. Dent was aware, that the principle of his suspension bed had been successfully adopted by Mr. Fox, in an instrument which he had constructed for taking the inclination many years since.—Mr. Dent was aware that Mr. Fox had adopted that mode of suspending a dipping needle, for it was he himself who executed the instrument for Mr. Fox; but this was the first attempt,

* M. Comte, ("Philosophie Positive," ii. 376, &c.,) the author of the reasoning alluded to, assures us that his calculations lead to results agreeing only approximately with the exact periods, a difference to the amount of 1.45, the part more or less existing in all. As he gives neither the steps nor the data of his calculations, it is impossible to trace the origin of this difference,—which, however, *must* arise from error *somewhere*, if his fundamental principle be really what he states. For the Huyghenian measure of centrifugal force $\left[F \times \frac{V_2}{R}\right]$ "combined" with "the law of gravitation $\left[F \times \frac{M+m}{R_2}\right]$, replacing V by its equivalent, $\frac{R}{P}$ can result in no other relation between P and R than what is expressed in the Keplerian law, and is incompatible with the smallest deviation from it.

Whether the sun threw off the planets or not, Kepler's law *must* be obeyed by them when once fairly detached. How, then, can their actual observance of this law be adduced in proof of their origin, one way or the other? How is it proved that the sun must have thrown off planets *at those distances, and at no others*, where we find them,—no matter in what times revolving? *That*, indeed, would be a powerful presumptive argument; but what geometer will venture on such a *tour d'analyse?* And, lastly, how can it be adduced as *a numerical coincidence of an hypothesis with an observed fact* to say that, at an unknown epoch, the sun's rotation (*not observed*) *must have been* so and so, *if* the hypothesis were a true one?

† Mill. Logic, ii. 28.—Also, "Vestiges of the Creation," p. 17.

he believed, ever made to suspend the ordinary azimuth compass in that manner.

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Magnetic Machine.—Dr. Scoresby described a large magnetic machine which he had constructed, with some results of its action. The principal part of the machine consists of two cases, or fasiculæ, of magnetic bars, of unusually large dimensions, on principles which may be thus summarily stated: 1. That magnetic bars designed for large combinations, may be conveniently constructed of various pieces; that the separation of a long bar, say of three or four into several portions, is not disadvantageous in regard to power, and that the resulting power is similar, whether in the combining of several series of short bars the elementary bars be of the same or of unequal lengths. 2. That the relative powers of magnets, whether single or compound, when different in mass, but proportional in all their dimensions, are not in the ratio of the masses, the large masses being less strong proportionally than the smaller. 3. That whilst magnets of large dimensions are less powerful with respect to their masses than small magnets to which they are exactly propotional in all their dimensions; and whilst the increase of the dimensions continually deteriorates from the energy due to the mass, yet magnets may be combined in such proportional dimensions with a constant increase of power *ad infinitum*. From this last result, it follows, that magnets indefinitely small must be indefinitely strong; and may indicate that the mutually attractive forces of the ultimate magnetic elements may be as strong as that by which the metallic elements are themselves combined. It must, also, be kept in mind, that the steel should be perfectly hard; and the elementary plates of the magnet should be made of steel, converted out of one or other of the very best qualities of common iron. All the conditions, with the exception of thinness, were attended to in the large magnet constructed by Dr. Scoresby. A magnet on this principle, of the size of the lower mast of a first-rate ship of war, would produce a deviation of nearly 1° at the distance of a mile, and a sensible effect much beyond that. The electrical effects of Dr. Scoreby's magnet with a very imperfect armature were—it decomposed water, rapidly producing about one cubic inch of the gases a minute; with about sixty-five yards of coiled wire, the effervescence seemed as violent as during the action of dilute sulphuric acid or zinc. Copper was deposited from a solution of sulphate of copper at the rate of about 1.2 grain per minute. Shocks and scintillations were thrown out; and sparks were visible in daylight, and emitted audible sounds when the armature revolved so slowly as once in sixteen seconds.

Prof. Forbes had little doubt that Dr. Scoresby could construct very powerful magnets; but he thought that as electro-magnets, so much more powerful, were so readily made, it was almost useless to incur the expense of the others.—Mr. Roberts described a magnet which he had constructed some four or five years since—but as an account was published at the time in the "Annals of Electricity," we need not report it again.

On the Actinograph, by Robert Hunt.—After referring to Daguerre's statement that the solar light, two or three hours before noon, was different in its chemical character from that which proceeded from the sun at equal times after it had crossed the meridian, the author proceeded to state from his own researches, that he was satisfied that the amount of chemical power was not in direct ratio with the quantity of light, but that at different hours of the day, and at different seasons of the year, a remarkable variation may be found to exist. The peculiar conditions of plants in the morning and evening, and the phenomena of hybernation, were referred to variations in this chemical (actinic) power, and the processes of germination, of flowering, fruiting, and the autumnal decay of the leaf, shown to be in all probability dependent upon the same influence. This being the case, it became desirable that some *self-registering* means of marking the changes in the condition of the sun's rays should be adopted. The actinograph is intended for this purpose. It consists of a cylinder of brass, upon which is placed a sheet of photographic paper, so prepared with the bromide of silver that all the rays of the prismatic spectrum shall act upon it with equal intensity; over this is placed another cylinder, which is carried round by a clock movement once in the twenty-four hours. In this outer cylinder is a triangular opening, divided by bars into a hundred parts, the smallest part of the slit being one hundred times less than the largest. As this cylinder moves over the paper it is of course exposed for different periods of time to the solar influence over different parts of the divisions; one portion being only exposed for one minute, whereas the largest opening admits of an exposure for one hundred minutes. Thus the greatest intensity of actinic power will produce, during the time of least exposure, the same effect as is produced by the weakest radiations during the period of prolonged exposure. The papers are removed every night and divided into twenty-four parts, and we have hence an exact measurer of the amount of chemical power exerted during every hour of daylight; and as the results may be numerically registered, and the uncertain effects of fixing thus removed, we procure with attention an accurate record for any period of time. This instrument is a modification of one devised by Sir John Herschel, with some improvements suggested by Mr. Jordan. Mr. Hunt stated that circumstances had prevented his doing more than to make a few trials of the apparatus, but that he hoped after the meeting to fix it, and use the actinograph for constant registration.

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Gases from Furnaces.—Prof. Bunsen and Dr. Lyon Playfair, (first part of the Report "On the Gases from Furnaces,") "On the eudiometric method of analysis employed in the inquiries on the manufacture of iron, and the gases evolved in the distillation of coal." The authors described in the first instance their method of collecting the gases from the furnaces, which they had succeeded in doing from every part of the iron furnaces, and this in England, Norway, and Sweden. The imperfect state of eudiometry was dwelt on, and the

mode adopted by the authors described; but as the details necessarily involve a number of purely chemical questions, we shall only refer to the more interesting facts. By the improved method the condition of the atmosphere was first ascertained, and the average of many experiments gave as its composition—

| | |
|---|---|
| Nitrogen, | 70.09 |
| Oxygen, | 20.91 |

which is nearly the result obtained by other eminent chemists. The analyses of the various carburetted hydrogens, collected from coal and coke, were next detailed, and many improvements named, particularly that the perchloride of antimony completely absorbed all the carburetted hydrogens, whether the fire-damp, or the olefiant gas, allowing the carbonic oxide and carbonic acid to pass freely, which were afterwards collected and ascertained in the usual manner. The gases proceeding from iron furnaces were found to be—

1. Nitrogen.
2. Ammonia.
3. Light carburetted hydrogen.
4. Olefiant gas.
5. Carbonic oxide.
6. Carbonic acid.
7. Carburetted hydrogen of unknown composition.
8. Aqueous vapor.
9. Hydrogen.
10. Sulphuretted hydrogen.

The gasification of coal in the furnaces takes place in two different points, in the first instance during the distillation of the coal and the formation of coke; and secondly, when the coke undergoes the process of combustion. This result was uniformly observed, and the authors verified it by subsequent experiments on artificial arrangements. The analysis of coal by dry distillation gave—

| | |
|---|---|
| Coke, | 68.92 |
| Tar, | 12.23 |
| Water, | 7.61 |
| Light carburetted hydrogen, | 7.04 |
| Carbonic oxide, | 1.13 |
| Carbonic acid, | 1.07 |
| Olefiant gas, | 0.75 |
| Sulphuretted hydrogen, | 0.75 |
| Hydrogen, | 0.50 |
| Ammonia, | 0.17 |
| Nitrogen, | 0.03 |
| Condensed hydrocarbon, | 0.00 |
| | 100.00 |

In the Second part of the Report the practical application will be detailed.

ASHES OF WHEAT.—Mr. W. Sharp noticed that the amount of the ashes of wheat was given from Sprengel as 1.177 per cent., whereas Sprengel himself (page 446, vol. 2, of his "Chemie für Landwirthe," &c.) states it to be 1.777; Dr. Daubeny, on the other hand, gives Sprengel's analysis as 2 137;—both on the supposition of a misprint in Sprengel's book. This led Mr. Sharp to undertake some experiments in order to ascertain the truth; and one suggestion arising out of another, about a hundred experiments were performed, with great care, on varieties of red and white wheat, grown on different soils and climates in England, Germany, Sweden, Poland, Holland, and Saxony. Ultimately, answers to the following questions were sought and apparently found:—1st. What is the average amount of inorganic matter in the grain of wheat? From 1.5 to 1.75 per cent. 2d. What is the difference in the result obtained from the combustion of wheat which has been previously dried at different temperatures? A great number of experiments were made by drying at temperatures of 245°, 260°, and 60°, and the difference of result was shown to be considerable. 3d. Can any temperature be recommended as the one to be preferred, at which the materials for these and similar experiments should be dried? The result of the experiment alluded to in the previous answer was in favor of the temperature of 60°. 4th. Can any chemical preparation be added to the substances experimented upon, before or during the combustion, which will facilitate the otherwise tedious process? Several substances were tried, particularly nitric acid, but they all failed to give satisfactory results. The per centage left by nitric acid was always less, but not uniformly less, than it ought to have been. 5th. Does the quantity of inorganic matter bear any relative proportion to the specific gravity of the grain,—that is, to its weight per bushel? The experiments show that a steady *inverse ratio* is maintained between the proportionate weight per bushel and the amount of ashes. Wheat weighing 64 lbs. per bushel yields 1.5 per cent.; and this amount gradually increases, till wheat weighing 58 lbs. per bushel gives 1.75 per cent. 6th. The practical question then follows: How much inorganic matter is removed from the soil of an acre of land by the grain of a crop of wheat? The answer is, one pound per bushel.

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"ON THE VOLTAIC REDUCTION OF ALLOYS," BY C. V. WALKER.—This communication was intended to explain the methods by which the author has succeeded in throwing down metallic alloys from compound solutions by the action of galvanic electricity. The process adopted, is to prepare a strong solution of cyanide of potassium, and commence electrolyzing it, by means of a copper anode; as soon as copper begins to be dissolved, the copper anode is removed, and its place supplied with one of zinc; after the action has continued for some little time, brass will be liberated on the cathode. The solution is now ready for use, and is operated upon by two or three Daniell's

cells, and with a brass anode. By similar means alloys of gold and copper, or gold and silver, may be deposited. The author reasons, that true brass is a definite chemical compound; and states—it appears possible that the anode, which is a brass of commerce, is a true alloy, plus an excess of zinc; that the solution it produces is a mixed solution, which consists of the potassio-cyanide of brass and the potassio-cyanide of zinc. This solution is very readily decomposable: it is therefore necessary to prepare it a short time previously to its use. Many specimens were exhibited of copper and other metals coated with brass. The author makes some remarks on the theory of the action; and concludes by stating that it will be quite possible to determine, within certain limits, the character of the alloy that shall present itself, and that we may be enabled to throw down gold and silver according to standard.

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"On the Influence of Friction on Thermo-Electric Phenomena," by Prof. P. Erman.—This communication was made by his son, M. Adolphe Erman, who had been invited to the Magnetical Conference.

M. Paul Erman examined the influence which friction at the point of contact of two heterogeneous metals exercises on the needle of a Nobili multiplier, combined with the metals. He then briefly recapitulated the history of this part of electrical science, and resumed by saying, that between the two extremes of electric omnipotence and of electric nullity, which have been attributed to the friction of conductors, he endeavored to find out the mean course of truth. The first step he reached in this career by a great variety of experiments, (on different groups of metals, their primitive temperatures being equal to that of the surrounding space, or lower or higher than it,) was, that the effect of such friction is always like that of an addition of heat to the point of contact. This was shown, among other methods, by the fact that groups of metals which, by difference of temperature, give rise to an electric current of an anomalous weakness or direction, act similarly when rubbed. This applies to galena, sulphuret of molybdena, and some others. In allusion to this intermediate office of heat, our author calls the dynamical electricity produced by the friction of conductors, the tribo-thermic electricity. But now the wonders and paradoxes which happen where things are in the *status noscendi* present themselves once more in this case; but when exerting its tribo-thermic effect, it is neither like conducted heat nor radiant heat. Indeed, its production when friction commences, and its disappearance when friction ceases, prove entirely independent of the mass of the rubbing bodies; and almost independent, also, of the duration of the process which produces it. M. Erman points out, that these remarkable facts seem to be highly favorable to the supposition of a peculiar kind of molecular vibration, excited exclusively in the rubbed points, and spreading through the conducting medium as instantaneously as electricity does. Connected with this fact is a circumstance which M. Erman thinks will be used for the measure-

ment of tribo-thermic effects, almost in the same way as the two fixed points of our thermometers are used for temperature, viz: there exists, for any group of thermo-electric metals, a given positive and a given negative difference, between their temperature and that of the surrounding space, which, when previously existing at the point of contact, continued friction will have no further influence on the electric current. In another part of this valuable paper, M. Erman reports some facts connected with the brilliant discovery of Peltier, that, according to the direction in which it travels, an electric current can as well cool as heat the point of contact of heterogeneous metals. He examined the effect of friction on bismuth and antimony in the four following cases:—

| When heated. | When at the temperature of surrounding space. | When cooled. |
|---|---|---|
| Antimony. | Bismuth. | |
| Bismuth. | Antimony. | |
| | Bismuth. | Antimony. |
| | Antimony. | Bismuth. |

and he found, that the same act of friction produces in these different cases, and with regard to the different metals, at one time a gain of electricity accompanied by a gain of heat, at another time a loss of electricity with a gain of heat; again, either a loss or gain of electricity joined to a loss of heat: and asks, may it be hence inferred that heat when nascent has a property specifically different from that of heat residing in a metal? Are we perhaps on the eve of finding at length something analogous to the brilliant discovery of Peltier, that galvanic electricity produces heat when proceeding from antimony to bismuth; and cold when traveling in the opposite direction? by which M. Lenz has produced congelation. M. Erman's chief object in communicating this paper to the British Association was, to excite British philosophers to engage in this almost new branch of investigation of tribo-thermic electricity. At the same time, he excuses the imperfections of the investigations submitted, by the extreme difficulties of such delicate experiments. Among these, he particularized the almost unavoidable influence of heterogeneous rheophores, which must be joined to the metals under examination. This difficulty caused him wholly to reject the first set of his experiments, until at last he found that the interposition of a plate of pure plumbago between each metal and its conducting wire proves an excellent means for limiting the anomalous production of electricity, without lessening the conducting power of the system. In conclusion, M. Erman suggests an important practical application of this tribo-thermic electricity. Instead of the voltaic apparatus in an electric telegraph, which is variable in its effects and expensive in its application, and may by use get deranged or incapable of action, perhaps at a moment when most required, he proposes to substitute this purely mechanical mode of exciting electricity, so as to affect a distant magnetic needle, and thus transmit signals. It is accomplished by simply removing a detent from a piece of clockwork, when a disk of bismuth rubbing

against one of antimony excites the distant needle. He has tested the method for tolerably long distances.

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"On the Baron de Bode's Insulated Compass," by J. Y. Oliver. —The object was to insulate the compass from the action of the iron of the ship. The contrivance was this: a double glass bowl, the intermediate space being filled with mercury, was made to act as the bowl of the ordinary compass. It was hung in gymbals, and protected with lead. This rendered it very heavy and cumbrous.

Mr. Dent objected, that if this insulation would protect the needle from the action of the ship's iron, it would also shield it from the directive force of the earth, and therefore render it useless: but upon placing a poker near the compass, it was distinctly affected through the insulating mercury.

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"On M. Kreil's Self-Registering Meteorological Instruments," by Baron Von Senftenberg.—The self-registering instruments of M. Kreil register at intervals of 5′ continually the state of the barometer, of the thermometer and of the hygrometer. The instruments are placed at Prague and at Senftenberg, which is nearly due east of Prague, about 100 English miles distant. It is situated on the Adler, 1281 Paris feet above the level of the sea, in latitude 50° 8′ 8″, and longitude east of Greenwich 1h. 5′ 46″ .98; situated on lias and mica slate, and near higher grounds of granite, gneiss and old red sandstone, and considerable forests. Prague is in a more level country, with the river Moldau flowing through it in a breadth of about 200 fathoms: it is only 524 feet above the level of the sea, without much wood land in its neighborhood; the surrounding hills being lias, sandstone, and argillaceous schist. The Baron then exhibited the dotted curves produced by the instruments, and the curves and mean curves and tables deduced from them; and showed their use, by comparing the curves of Senftenberg with those of Prague, in informing us at which the changes began to occur first; this was readily inferred from the coincidences of the curves after having arrived at maxima and minima;—and concluded by pointing out, as an exemplification of their utility, the curious relations at each place during some remarkable thunder-storms.

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"On the Strength of Stone Columns," by Mr. E. Hodgkinson. —The columns were of different heights, varying from one inch to forty inches; they were square uniform prisms, the sides of the bases of which were one inch and one and three quarters inch, and the crushing weight was applied in the direction of the strata. From the experiments on the two series of pillars it appears that there is a falling off in strength in all columns from the shortest to the longest; but that the diminution is so small, when the height of the column is not greater than about 12 times the side of its square, that the strength may be considered as uniform, the mean being 10,000 lbs. per square inch, or upwards. From the experiments on the columns one inch

square, it appears that when the height is 15 times the side of the square the strength is slightly reduced; when the height is 24 times the base, the falling off is from 138 to 96 nearly; when it is 30 times the base, the strength is reduced from 138 to 75; and when it is 40 times the base, the strength is reduced to 52, or to little more than one-third. These numbers will be modified to some extent by the experiments in progress. In all columns shorter than 30 times the side of the square, fracture took place by one of the ends failing—showing the ends to be the weakest parts; and the increased weakness of the longer columns over that of the shorter ones seemed to arise from the former being deflected more than the latter, and therefore exposing a smaller part of the ends to the crushing force. The cause of failure is the tendency of rigid materials to form wedges with sharp ends, these wedges splitting the body up in a manner which is always pretty nearly the same; some attempts to explain this matter theoretically were made by Coulomb. As long columns always give way first at the ends—showing that part to be the weakest—we might economize the material by making the areas of the ends larger than that of the middle, increasing the strength from the middle both ways towards the ends. If the area of the ends be to the area in the middle as the strength of a short column is to that of a long one, we should have for a column whose height was 24 times the breadth, the area of the ends and middle as 13,766 to 9,595 nearly. This, however, would make the ends somewhat too strong; since the weakness of long columns arises from their flexure, and increasing the ends would diminish that flexure. Another mode of increasing the strength of the ends would be that of preventing flexure by increasing the dimensions of the middle. From the experiments it would appear that the Grecian columns, which seldom had their lengths more than about ten times the diameter, were nearly of the form capable of bearing the greatest weight when their shafts were uniform; and that columns tapering from the bottom to the top were only capable of bearing weights due to the smallest part of their section, though the larger end might serve to prevent lateral thrusts. This last remark applies, too, to the Egyptian columns, the strength of the column being only that of the smallest part of the section. From the two series of experiments, it appeared that the strength of the short column is nearly in proportion to the area of the section, though the strength of the larger one is somewhat less than in that proportion.

Prof. Challis inquired whether Mr. Hodgkinson had found the columns to give way chiefly in the direction of the cleavages of the stone? Mr. Hodgkinson replied that he had; and that hence the same size and shape of stone cut out of the same block, required very different forces to crush them against the grain from what they did with it. Prof. Stevelly said, that it was one peculiarity of Mr. Hodgkinson's researches, that they opened up so many collateral objects of interest and wide fields of inquiry. It was easy to see that the present researches might become important to the geologist, by leading him to the source from which originated the splitting up of extended rocks into beds and strata, and the contortions of them; for